THE INFLUENCE OF PERCEPTION, RECESSION AND INCOME STRATA ON CONSUMER DEMAND FOR PROTEIN SOURCES

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Abstract:

U.S. Consumers see retail beef products in the meat case labeled as produced with no added hormones (NAH). However, they also see similar labels on pork and chicken products despite the fact that added hormones are not used in pork and poultry production. Such labeling may mislead consumers to believe that hormones are used in pork and poultry production. This dissertation examines the impact of hormone use perception on consumer preference for meat products. Results suggest that consumer perceptions of hormone use in production are incorrect. Further, perception influences consumer preferences and willingness-to pay (WTP) for unlabeled products versus NAH labeled products.

Given that most consumers have little direct involvement in food production, many food choices are likely made with inaccurate beliefs regarding production claims. If consumers have factual information about food production to inform their perception, they may make different choices about products and WTP, potentially increasing utility. This dissertation demonstrates the impact of factual hormone use information on consumer preferences for meat products. Results reveal that after consumers receive factual hormone use information, demand for beef products decreases while demand for pork and chicken products increases. Consumers are willing to pay more for NAH labeled meat products both pre- and post-information. However, WTP premiums for NAH labeled pork chops and chicken breast become lower post-information.

A primary driver of consumer demand is income. The U.S. economy experienced a significant economic recession from December 2007 through June 2009. Median household income started to fall in 2007 and did not rise again until 2012. Consumers have multiple options to consider in rearranging their shopping basket to satisfy daily protein consumption under financial pressure. However, the timing of such behavioral change is unknown. Further, low, middle and high-income households may vary in protein source expenditure responses to financial pressure. This dissertation analyzes whether and how consumer demand for protein sources was impacted by the Great Recession. Results suggest the break date of expenditure patterns for protein sources is around October 2009. Changes of own-price and expenditure elasticities for protein sources are different for households across income quintiles after October 2009.

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CHAPTER I

INTRODUCTION

Consumer behavior is the study of individuals, groups, or organizations and the processes they use to select, secure, use, and dispose of products, services, experiences, or ideas to satisfy needs and the impacts that these processes have on the consumer and society (Kardes, Cronley and Cline, 2011). It attempts to understand the decision-making processes of buyers. Psychological factors, personal factors, and social factors play crucial roles in determining consumer decisions. Understanding consumer behaviors may allow companies to increase market share by anticipating the shift in consumer wants, and helps policymakers design effective policies.

A recent example of a change in consumer behavior is the compound of meat purchases. Over the past decade, U.S. overall meat consumption declined nearly 11%: beef consumption dropped 15%, pork consumption fell by 4%, and broiler consumption increased 5% (USDA, 2016). My research will focus on the influence of consumer perception, recession and income strata on protein sources, including meat purchases, with implications for industry marketing decisions, and for policy relevant to the industry.

The rise of food label claims has caused food choices to become complex decisions. Consumers typically consider brand, price, shelf life, and nutrition when they purchase food products. Food production practices become a new set of attributes for consumer consideration. For many consumers, buying chicken becomes more complex than deciding whether to buy chicken breast or chicken wings at a suitable price and expiration date. They are concerned about how chickens were raised, including production practices related to feed content, growth hormones and antibiotics for example.

Food labels help provide answers. However, sometimes food labels may add confusion. Consumers see retail beef products in the meat case labeled as produced with no added hormones (NAH). However, they also see similar labels on pork and chicken products despite the fact that added hormones are not used in pork and poultry production. Such labeling may mislead consumers to believe that hormones are allowed in pork and poultry production. What are consumer perceptions of hormone use in production of beef, pork and poultry? Does consumer perception of hormone use affect demand for beef, pork or chicken? These questions are of interest to meat producers, consumers and policy makers. Policy makers may be interested in the legality of labels that lead to inaccurate perceptions. Poultry and pork producers who use NAH labels may be unaware of the externality imposed on the sector as a whole if overall demand is dampened by perceptions of hormone use.

Knowledge of consumer perception of hormone use across different livestock species can increase our understanding of purchase decisions for various meat products. Consumer beliefs affect choice, thus measuring consumer beliefs in studies of consumer choice is needed (Lusk, Schroeder and Tonsor, 2014). Economists have frequently studied the impact of hormone use on consumer preference for food products. For example, Lusk, Roosen and Fox (2003) compared consumer valuation of steaks from cattle produced with and without added hormones. However, those studies do not account for consumer perceptions of hormone use in meat production. Willingness to pay (WTP) estimates for meat products may be improved by distinguishing consumer perception of hormone use for different livestock species from preference for meat products.

Given that most consumers have little direct involvement in food production, many food choices are likely made with inaccurate beliefs regarding production claims, particularly for credence attributes where the attribute is not visibly observed. Consumer beliefs about food attributes play an important role in their food choices. If consumers have factual information about food production to inform their perception, they may make different choices about products and WTP, potentially increasing utility. Therefore, if consumers are given the actual hormone use information, will their preference for meat products change?

The U.S. economy experienced a significant economic recession from December 2007 through June 2009 (NBER, 2012). Median household income started to fall in 2007 and did not rise again until 2012. In fact, median household income in 2015 was 1.6 percent lower than in 2007 (U.S. Census Bureau, 2016). Decreasing incomes may influence consumer expenditure patterns on protein sources. Previous research often defines break dates (i.e. points of structural change) according to the event. For example, Okrent and MacEwan (2014) chose 2008, the beginning of great recession as a break date and compared the elasticities of demand for nonalcoholic beverages between pre-recession (1999-2007) and recession and post-recession periods (2008-2010). However, income change may have an immediate impact or may also have a lagged effect on expenditure pattern changes for protein sources because consumer purchasing habits change gradually and because recessions happen over time rather than at a point in time.

Most food demand studies are implemented from the perspective of food types, such as meats, vegetables and fruits, rather than nutritional categories. Demand for protein is an important nutritional category. Many food policies and food assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP), are targeted at low-income households with the intent of improving participants' nutritional status. Quantitative information on demand for protein sources across different income groups can inform public policy. Since meat, including beef, pork and poultry, is the primary protein source in the U.S., a large body of research has focused on factors that influence meat demand. Examining the influence of recession and income strata on protein sources, including both meat and non-meat sources, brings a new perspective on meat demand.

The purpose of this dissertation is to identify the influence of perception, recession and income strata on consumer demand for protein sources. The following are the objectives of this dissertation:

- Demonstrate the impact of hormone use perception on consumer preferences for meat products.
- Present the impact of information about factual hormone use in livestock production on consumer preferences for selected meat products.
- Analyze whether and how consumer demand for protein sources was impacted by the Great Recession.

CHAPTER II

IMPACT OF HORMONE USE PERCEPTIONS ON CONSUMER MEAT PREFERENCES

Introduction

It is estimated that more than 90 percent of all U.S. feedlot cattle are administered with hormones to improve growth rates and feed efficiency[1] (USDA, 2013). Currently, federal regulations do not allow hormone use in poultry (chickens, turkeys, ducks) or swine production[2] (USDA, 2015). Given the prevalence of news and information about hormone use (Cattle network, 2012; FDA, 2015; Organic Consumers Association, 2007;

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[1] Six different kinds of steroid hormones are currently approved by Food and Drug Administration (FDA) for use in beef production: estradiol, progesterone, testosterone, zeranol, trenbolone acetate, and melengestrol acetate (FDA 2015).

[2] In poultry and swine production, other non-hormone growth promotants are used. Beta-agonists (e.g. Ractopamine) are widely used in swine production to enhance lean muscle gain and feed conversion. They work at a cellular level without affecting hormone levels of the animal (American Meat Science Association, 2015). Beta-agonists, such as ractopamine and zilpaterol hydrochloride were estimated to be used in 60% to 80% of feedlot cattle in the U.S. in 2013 (Micik, 2013). Though zilpaterol was pulled from the market in 2013 to further examine its impact on animal welfare, other beta-agonists are still in use.

Health, 2016), consumers may perceive that the prevalence of hormone use in the meat industry as a whole is very high. Research indicates that hormone use in cattle does not pose a risk to human beings or the environment and its use is approved by FDA (Capper and Hayes, 2015; Cattle network, 2012; FDA, 2015). Still, consumer concerns exist regarding hormone use, including potential health risks (Lusk and Schroeder, 2014; Tonsor and Schroeder, 2009).

Consumer concern about the safety of hormone use in livestock production is relatively high. A study conducted by the Food Marketing Institute (1995) found that 50% of consumers said hormones were a serious hazard. Lusk, Fox and McIlvain (1999) found that consumer concern about animal growth enhancers, including hormones, was higher than concern for additives, preservatives, and antibiotic use, but lower than concern for bacteria, spoilage, and chemicals. Moreover, research shows that consumers do not always equally believe the information on probabilities presented in advertisements, experiments or surveys (Hayes et al., 1995). Teisl and Roe (2010) show that people's perceptions of the likelihood of getting sick from food borne illness can differ from actual probabilities of food contamination. Similarly, consumer perception of hormone use for different livestock species may differ from reality. The introduction of food labels can also create uncertainty and influence beliefs about the quality of unlabeled products (Dannenberg, Scatasta and Strum, 2011).

Consumers see retail beef products labeled as produced with no added hormones (NAH), but also see similar labels on pork and poultry products on market shelves despite the fact that added hormones are not used in production. This may mislead consumers to believe that hormones are also used in pork and poultry production. What are consumer perceptions of hormone use in production of beef, pork and poultry? Does consumer perception of hormone use affect demand for beef, pork or chicken? These questions are of interest to meat producers, consumers and policy makers. Policy makers may be interested in the legality of labels that lead to inaccurate perceptions. Poultry and pork producers who use NAH labels may be unaware of the externality imposed on the sector as a whole if overall demand is dampened by perceptions of hormone use.

Knowledge of consumer perception of hormone use across different livestock species can increase our understanding of purchase decisions for various meat products. Consumer beliefs affect choice, thus measuring consumer beliefs in studies of consumer choice is needed (Lusk, Schroeder and Tonsor, 2014). Lusk, Schroeder and Tonsor (2014) suggest willingness to pay (WTP) can be better understood by distinguishing beliefs from preferences in food choice. Willingness to pay estimates for meat products may be improved by considering consumer perception of hormone use for different livestock species. In addition, econometric approaches that do not account for differences in beliefs across people may yield misleading estimates of welfare changes (Marette, Roe and Teisl, 2012). The inclusion of consumer perceptions of hormone use in livestock production could improve measures of the welfare implications of meat product labeling.

The purpose of this paper is to identify the impact of hormone use perception on consumer preference for meat products. Specifically, we assess consumer perceptions of hormone use in different livestock species. We then assess whether consumer perception of hormone use affects choices for unlabeled meat products. Finally, we identify whether consumer perception of hormone use affects stated WTP premiums for meat products labeled as NAH.

Background

Economists have conducted many studies about the impact of hormone use on beef demand. For example, Lusk, Roosen and Fox (2003) compared consumer valuations of beef ribeye steaks from cattle produced with and without growth hormones or genetically modified corn in France, Germany, the United Kingdom, and the United States. These results indicate that French consumers place a higher value on beef from cattle that have not been administered added growth hormones than U.S. consumers. Platter et al. (2003) reported that consumer ratings of beef palatability are affected by the use of hormonal implants on cattle. They found that steaks from non-implanted steers were rated as more desirable for overall eating quality than steaks from implanted steers.

Capper and Hayes (2015) quantified the environmental and economic impact of withdrawing growth-enhancing technologies (GET), including hormone implants, from the U.S. beef production system. They concluded that withdrawing GET from U.S. beef production would reduce both the economic and environmental sustainability of the industry. To date, the accuracy of consumer perceptions regarding the prevalence of hormone use in cattle, hogs and chicken production has not been examined. In addition, studies regarding consumer preference for NAH products have been limited to beef, since hormones are not used in pork or chicken production. However, if perceived hormone use differs from actual use, WTP for pork or chicken products labeled as NAH may be impacted.

Many studies elicit consumer WTP for various beef products and for health and environmental outcomes (Adamowicz, 2004; Dannenberg, 2009; Grunert et al., 2009; Lagerkvist and Hess, 2011). However, this large body of applied work often does not explicitly separate WTP estimates into consumer beliefs and preferences for product attributes. Most WTP studies are constructed such that attributes are assumed to be known with certainty and beliefs across people are the same. Conversely, Lusk, Schroeder and Tonsor (2014) showed that controlling for subjective beliefs can substantively alter the interpretation of WTP and the ultimate implications derived.

Willingness to pay may be closely related to consumer beliefs about attributes in addition to demographic and socio-economic characteristics. Lusk (2011) estimated the linear effects of demographics and consumer food values on relative preferences for organic food using choice experiment data. His results indicated that the model including relative price changes, consumer food values and demographic variables is the most preferred specification as compared to models without demographics.

Data and Methods

Data were collected by appending survey questions to Oklahoma State University's monthly Food Demand Survey in May 2016. The Food Demand Survey is an online survey conducted monthly (Lusk, 2017). Each month over 1,000 completed surveys are obtained. The sample size yields a 3% sampling error with 95% confidence interval for dichotomous choice questions. A total of 1,023 consumers responded to the May 2016 survey.

Subjects were asked to indicate their perception of the prevalence of hormone use in production of different livestock species, including beef cattle, pigs, and broiler chickens (Figure 2.1). Standard t-tests are then used to examine whether consumer perception of hormone use rates in meat production across cattle, hogs and chicken differ from actual use in production.

Subjects were also asked to make 9 discrete choices (Figure 2.2). In each choice, subjects chose from 8 types of food products including hamburger, steak, pork chop, ham, chicken breast, chicken wings, bean, pasta and a "no purchase" option. Prices of each food product varied across the 9 choices. The choice experiment data is analyzed using a random utility model (McFadden, 1973) in which a preference parameter is estimated for each meat product and for price as

(1) $$EU_j = \gamma_j - \alpha Price_j$$

where EU_j is expected utility of product j, $Price_j$ is the price of product j, and γ_j is the fixed effect of product j which incorporates beliefs about hormone use in food product j.

The random expected utility model (Savage, 1954) is estimated as

(2) $$EU_{ij} = \gamma_j + B_{ij}U(H) - \alpha Price_j$$

where B_{ij} is subject i's belief regarding degree of hormone use in product j, $U(H)$ is the relative preference for hormone added product over NAH product. The preference for NAH, $U(NH)$, has implicitly been normalized to zero. The result is that $U(H)$ represents the difference in utilities from the hormone added attribute of a product and the NAH attribute of a product. $U(H)$ is expected, though not restricted, to be non-positive. This allows isolation of the relative contributions of hormone added from the overall preference for product j.

An additional consideration is that consumers' relative preference for NAH meat can vary across different species. The random expected utility model then becomes

(3) $$EU_{ij} = \gamma_j + B_{ij}U(H)_j - \alpha Price_j$$

where $U(H)_j$ is relative preference for hormone added product j over NAH product j. We allow relative preferences for hormone added product meat products to differ from each other.

A primary objective is to relate consumers' hormone use perceptions to their purchases of meat products. However, the traditional conditional logit model (McFadden, 1973) assumes that all individuals in the sample have the same level of preference for hormone use rate. To overcome this weakness, we also estimate the expected utility model in Equation 3 using latent class model (LCM) (Boxall and Adamowicz, 2002). In latent class models with different number of classes, we select the one with the smallest AIC number where each class represents at least 10% of the sample.

The -2 Log L and AIC model selection criteria are both used to test whether random expected utility modes (Equations 2 and 3) fit the data better than the conventional model (Equation 1). Meat product demand is then analyzed for 1) consumer perceived hormone use rates, 2) actual hormone use rates, and 3) NAH (only for cattle). The demand for meat product j given a particular choice set J is

(4) $$D_j = \frac{e^{EU_j}}{\sum_{k=1}^{J} e^{EU_k}}$$

where D_j is demand (or market share) for meat product j, EU_j is expected utility of product j, EU_k is expected utility of k^{th} product in meat choice set J.

In the survey, willingness-to-pay premiums are solicited for meat products labeled as produced with NAH with the highest premium payment set to five dollars per pound (Figure 2.3). In addition, standard questions about subjects' demographic information were asked, including farm experience, age, household income, education level, regions and presence of children in the household. Since consumer perceptions may vary across demographic groups, we examine whether WTP premiums for meat product labeled as produced with NAH are affected by consumer perception of hormone use and demographic factors. Demographic factors include farm experience, age, household income, education level, regions, and presence of children in the household. The Tobit model is chosen for estimation since maximum WTP premiums are censored with an upper bound of $5/lb.

Results

Consumer perception of hormone use prevalence in production ranged from 0 to 100% for each species considered (Figure 2.4). Perception patterns are similar across species with peaks near 50% and near 100% for each species. The average perceived hormone use rate is approximately 62% for cattle, 55% for hogs, and 57% for chickens. Based on standard t-tests, consumer perceived hormone use rates are significantly different from actual hormone use rates at the 99% level. On average, consumers underestimate hormone use in beef production and overestimate hormone use in pork and poultry production.

Table 2.1 reports results of three model specifications fit to the choice experiment data, including the conventional model (Equation 1), a random expected utility model incorporating beliefs and identification of preferences for hormone added (Equation 2), and the modified random expected utility model allowing different preferences for hormone added ($U(H)$) across meat products (Equation 3). Each of the three model specifications was estimated using conditional logit. The modified random expected utility model was also estimated using a LCM.

Magnitude and significance are similar across models using a traditional conditional logit method. Both -2 Log L and AIC model selection criteria clearly favor the expected utility models separating beliefs over the conventional utility model. Consumers derive the highest utility from steak and the least utility from ham among meat products across all three conditional logit models. Marginal utility of hormone use rate ($U(H)$-$U(NH)$) is negative in the random expected utility model, indicating that if a consumer believes a meat product is hormone added, he is less likely to choose the meat. Marginal utilities of hormone use rate for individual meat products are also negative in the modified random expected utility model. The marginal utility of hormone use rate is highest for steak (0.554) and lowest for ham (0.125). Generally, marginal utilities of hormone use rate are higher for high value cuts within a species and lower for lower value cuts within a species.

The preference heterogeneity found in the modified random expected utility model (Table 2.1) shows significant differences amongst members of four different classes in LCM. The first latent class (Steak Lovers) shows a relatively high steak coefficient value relative to coefficients on other attributes. This group of consumers (33% of sample population) represent a traditional American shopper that enjoys having steak as part of their diet. This group's utility from burger, steak, pork chop and chicken breast are also relatively higher than other products, and marginal utilities of hormone use rate are negative for burger, steak, pork chop and chicken breast. This group may have more concern about hormone use in high value meat products since their utility from high value meat is higher. Coefficients in Class 2 reveal that consumers in this group lose utility from added hormones in steak, but not other meat products. This leads us to refer to the second class of consumers (20% of sample population) as ‘‘NAH steak lovers’’. In the third class (Vegetable lovers), many coefficients for meat products are negative while coefficients for beans and pasta are positive. Consumers in this group (12% of sample population) prefer purchasing nothing to meat, but obtain utility from beans and pasta. They are relatively indifferent about hormone use in meat with the exception of pork chops. In the fourth class, “Product Insensitive”, coefficients differ little across products. Consumers in this group (35% of sample population) may be characterized by shoppers with little differences in their preferences for meat products. Interestingly, they obtain utility from the hormone added attribute in pork.

Demand for the meat products included in the consumers’ choice set is affected by the perceived hormone use rate in different livestock species. Using parameter estimates from the LCM approach to Equation 3, we generate a representation of consumer preferences for meat products. Figures 5 through 8 show simulated demand graphs for the four different classes, including Steak Lovers, NAH Steak Lovers, Vegetable Lovers and Product Insensitive, respectively. These graphs reflect market share among the nine options in our choice experiment at various prices according to Equation 4. Three levels of hormone use rates are chosen to simulate demand for beef products, including no hormones (0%), actual hormone use (90%) and average perceived hormone use (62%). Two levels of hormone use rates are used for pork and chicken products, including no hormones (or actual hormone use, 0%) and perceived hormone use (55% for pork, 57% for chicken).

For “Steak Lovers” (Figure 2.5), the predicted market share for steak at the perceived hormone use rate (62%) is larger than for actual hormone use (90%) at any price, while the predicted market share for hormone free steak is the largest among the three hormone use levels. For example, among the nine meat products, if steak price is \$5.5/lb., the predicted market share for steak at the perceived hormone use rate (62%) is 9%, for steak with actual hormone use (90%) is 7%, and for hormone free steak is 14%. The impact of hormone use perception on Steak Lovers' demand for burger is similar to steak. This group's predicted market share for pork chops, ham, chicken breast and wings is larger for actual hormone use (none) than for perceived hormone use rates of 55% for pork and 57% for chicken.

"NAH Steak Lovers" (Figure 2.6) have predicted market shares for burger that are similar across hormone use levels. However, the demand for NAH steak is larger than the demand for steak at both the perceived (62%) and the actual (90%) hormone use rates. Predicted market share for pork chops, chicken breast and wings is larger for actual hormone use, which is zero, than for perceived hormone use rates of 55% (pork) and 57% (chicken). Ironically, demand for ham at the perceived hormone use level of 55% is slightly larger than with actual hormone use of zero.

"Vegetable Lovers" prefer to buy nothing if asked to choose between meat products and nothing. Although demand graphs (Figure 2.7) for "Vegetable Lovers" are simulated with negative prices since the standardized utility of no purchase is zero, the impact of hormone use perception on demand for meat products is similar to the group of "Steak Lovers". The difference of pork chop demands between actual (0) and perceived hormone use (55%) rates is large for "Vegetable Lovers".

In contrast, the "Product Insensitive" group (Figure 2.8) has predicted market shares for burger and steak that are similar across different hormone use levels, while demand for chicken breast at the perceived hormone use rate of 57% is smaller than with actual hormone use of zero. In contrast, predicted market shares of pork chops, ham and wings are larger for perceived hormone use (55% for pork, 57% for chicken) than for actual hormone use (0). In general, if consumers correctly perceived NAH in pork or chicken production, the market share for pork chops, ham, chicken breasts and wings would be larger.

Table 2.2 reports WTP estimates for meat products as compared to "no purchase" in our choice experiment. For "Steak Lovers", WTP estimates are higher for burger and steak with perceived hormone use (62%) than with actual hormone use (90%), and highest for NAH burger and NAH steak. Steak Lovers' WTP for pork and chicken products is lower with perceived hormone use (55% for pork, 57% for chicken) than actual hormone use (0). For example, WTP for a pork chop produced with the average perceived hormone use rate of 55% is \$0.60/lb. less than for a pork chop produced with actual hormone use of zero. The NAH Steak Lovers have a WTP for NAH steak that is \$1.45/lb. more than for steak produced with actual hormone use (90%). In general, our results suggest that more than 50% of consumers labeled as meat purchasers (Steak Lovers and NAH Steak Lovers) are willing to pay more for NAH claimed pork and chicken products because of their misperceptions of hormone use in pork and poultry products.

In our survey, we asked subjects about WTP premiums for meat products labeled as NAH. Consumers indicated that they are willing to pay more for meat products labeled as produced with NAH, as seen in the mean WTP values reported in Table 2.3. The WTP premiums at the mean are highest across the six meat products for NAH steak and lowest for NAH chicken wings. Table 2.4 reports results from three model specifications implemented to further analyze WTP premiums for meat products labeled as produced with NAH. Model 1 includes the consumer's perceived hormone use rate and indicates that WTP premiums for NAH labeled meat products are indeed sensitive to consumer perception of hormone use rate in different livestock species. Models 2 and 3 incorporate demographic characteristics. Model 2 focuses only on the linear effects of demographics on WTP premiums, while Model 3 also includes interaction effects between consumer demographics and perception of hormone use. The AIC and Log Likelihood values indicate that Model 3 is the preferred specification. Results indicate that consumer perception of hormone use is significantly related to WTP premiums for meat products labeled as produced with NAH.

Results suggest that the higher the hormone use rate perceived by consumers, the higher the premiums they are willing to pay for NAH labeled meat products. The WTP premiums for meat products labeled as produced with NAH are also affected by the value of the cut. For example, the WTP premium for NAH labeled steak is higher than for NAH labeled hamburger, the WTP premium for NAH labeled chicken breast is higher than for NAH labeled chicken wings, and the WTP premium for NAH labeled pork chop is higher than for NAH labeled ham. In general, WTP premiums for NAH labeled high value cuts are higher within species than for NAH labeled lower value cuts.

Model 2 and Model 3 indicate that demographic factors including farm experience, age, household income, education level, regions, and presence of children in the household also affect WTP premiums for NAH labeled meat products. Model 2 shows that females are willing to pay more for meat products labeled as produced with

NAH than males. The WTP premiums for NAH labeled meat products for consumers, who stated that they have farm experience are higher than for those without farm experience[3]. The WTP premiums for NAH labeled meat products are higher in groups with income of more than $140k than for lower income groups.

Model 3 also suggests that perceived hormone use rates affect WTP premiums for NAH labeled meat products differently across categories within a demographic variable. For example, WTP premiums for consumers with incomes higher than $160K are higher than for those with income of $140k-$159k (-0.921), but WTP premiums increase more slowly in response to an increase in perceived hormone use rate for consumers with incomes more than $160K than for those with income of $140k-$159k (1.969). That is, changes in hormone use perception have less effect on WTP premiums for NAH labeled meat products for the highest income (more than $160K) than those in the income range of $140k-$159k. In General, WTP premiums for NAH labeled meat products for lower income groups (<$79k) are lower than for higher income groups. Hormone use perception has stronger effect on WTP premiums for NAH labeled meat products in lower income groups (<$79k) than in higher income groups. Similarly, WTP premiums in households with children under 12 (0.713) is higher than for those with no child, but WTP premiums increase more slowly in response to an increase in perceived hormone use rate for households with children under 12 (-0.628) than without children.

[3] Lusk (2017) found that about 40% of survey respondents who state that they have farm experience worked on a farm that produces commercial livestock (e.g. cattle, swine, or poultry) in the March 2017 Food Demand Survey. Other respondents listing farm experience included working in backyard gardens, backyard chicken coops, and crop farms.

Generally, WTP premiums for NAH labeled meat products are higher for younger age groups than for older age group. Hormone use perception has a stronger effect on WTP premiums for NAH labeled meat products in the younger age groups (ages 18-44) than in the older age groups (ages 45-74). Regional differences are evident as well. The WTP premiums for NAH labeled meat products for people in the Far West are lower than for people in other regions. Hormone use perception has a stronger effect on WTP premiums for NAH labeled meat products for people living in the Far West, Great Lakes and the Southwest than for those in the Mideast, New England, Rocky Mountain, Southwest and the Plains.

Conclusions

Though consumers are concerned about hormone use in meat animals, our results suggest that most are not well-informed regarding actual use of hormones in production. While the average perceived hormone use rate is 62% for cattle, 55% for hogs, and 57% for chicken, the actual hormone use rate in cattle is more than 90% and there is no hormone use in swine or chicken production.

Consumer perceptions of hormone use prevalence in different meat animal species are shown here to be an important factor in meat demand. We examine how those perceptions affect consumer choices for various meat products. Results reveal that relative preferences for conventional meat products over NAH labeled meat products from cattle, hogs and chickens are negatively related to consumers' utility. Meat demand is also affected by consumers' misbeliefs about hormone use in different livestock species.

Consumers are willing to pay more for meat products labeled as NAH, relative to unlabeled products. The WTP premiums for steak labeled as NAH are higher relative to lower value meat cuts. The implication is that for high value meat products, consumers may care more about whether hormones are added in production. This is also supported by higher WTP premiums for high value cuts labeled NAH within a species.

"No added hormones" labels increased consumer WTP for the six meat products in the choice set, including pork and poultry products where hormone use is universally prohibited in U.S. production. This labeling claim may lead consumers to believe that the product is different or healthier than similar unlabeled products, while in reality, all poultry and pork products are NAH. In fact, the claim "no added hormones" cannot be used on the labels of pork or poultry unless it is followed by a statement that says "Federal regulations prohibit the use of hormones." (USDA, 2015). However, manufacturers may shrink, minimize, or obscure this statement of clarification. It is a challenge to deliver correct information to consumers by labeling claims.

Demand for pork and poultry may be unduly hampered by false beliefs about hormone use. If consumers correctly perceived NAH in pork or chicken production, our results suggest that the demand for pork and chicken products would be larger. Although producers may gain premiums from NAH labels on pork or poultry products, demand in general for pork and poultry may be dampened by consumers' misperception of hormone use. The NAH labels may actually perpetuate consumers' misperception of hormone use in pork and poultry production. Policy makers may wish to revisit the impact of NAH labels on pork or poultry products. Our results imply that the premiums from NAH labels on pork and poultry products could evaporate if consumers have correct knowledge of hormone use in pork and poultry production.

Consumer misbeliefs about hormone use in the meat industry affects food choices. Given that most consumers have little direct involvement in food production, many food choices are likely made with inaccurate beliefs regarding production claims. This article highlights the impacts that misperceptions can have on food choice and on willingness-to-pay for those food choices.

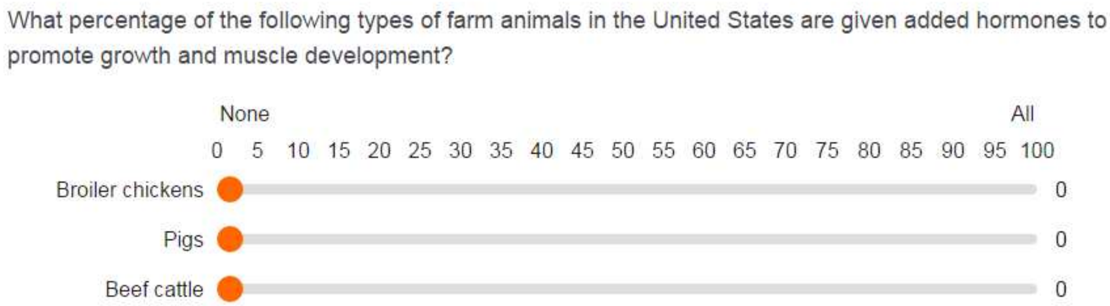


Figure 2.1. Survey question about perceived hormone use

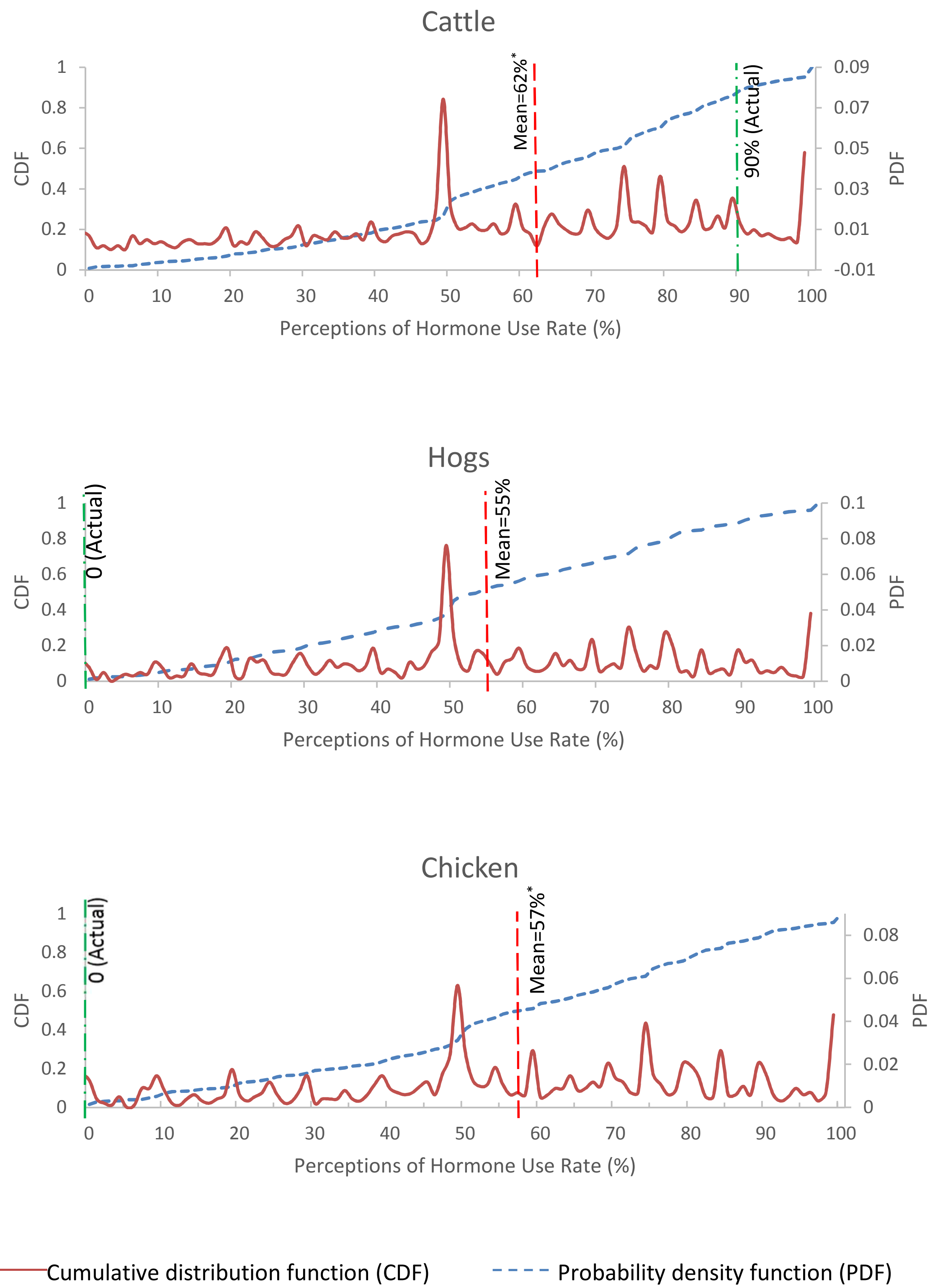
Figure 2.2. Example of choice questions

If you walked into your local grocery store and saw a package of meat with the label 'no added hormones', what is the highest **premium** you would be willing to pay for the following meats with this label over meats without this label?

Steak

$0/lb more
$0.50/lb more
$1.00/lb more
$1.50/lb more
$2.00/lb more
$2.50/lb more
$3.00/lb more
$3.50/lb more
$4.00/lb more
$4.50/lb more
$5.00/lb more or higher

Figure 2.3. Example of questions about willingness-to-pay premiums for NAH meat products



Note: Single asterisk (*) denotes statistical significance at 1% level.

Figure 2.4. Distribution of consumer perceptions of hormone use rate in cattle, hogs and chicken

Table 2.1. Parameter Estimates by Utility Model and Estimation Approach

Parameters (Utilities)	Conventional Model (Conditional Logit Model)	Random Expected Utility Model (Conditional Logit Model)	Modified Random Expected Utility Model				
			Conditional Logit Model	Latent Class Model			
				Class 1 "Steak Lovers"	Class 2 "NAH Steak Lovers"	Class 3 "Vegetable Lovers"	Class 4 "Product Insensitive"
-1 * Price	0.483*	0.483*	0.483*	1.238*	0.820*	0.329*	0.105*
	(0.011)	(0.011)	(0.011)	(0.398)	(0.045)	(0.437)	(0.025)
Burger vs. None	2.302*	2.579*	2.595*	5.021*	4.518*	-1.170*	3.515*
	(0.058)	(0.076)	(0.099)	(0.232)	(0.473)	(0.515)	(0.344)
Steak vs. None	3.429*	3.706*	3.774*	7.089*	6.925*	-0.613	4.124*
	(0.081)	(0.095)	(0.120)	(0.375)	(0.522)	(0.607)	(0.357)
Chop vs. None	1.979*	2.226*	2.296*	4.871*	5.136*	-0.548	2.826*
	(0.062)	(0.076)	(0.101)	(0.240)	(0.421)	(0.427)	(0.358)
Ham vs. None	1.089*	1.335*	1.160*	2.869*	1.437*	-1.991*	2.486*
	(0.060)	(0.074)	(0.113)	(0.215)	(0.778)	(0.622)	(0.341)
Breast vs. None	2.846*	3.102*	3.107*	4.938*	6.909*	-0.252	3.481*
	(0.054)	(0.071)	(0.080)	(0.189)	(0.370)	(0.323)	(0.344)
Wing vs. None	1.173*	1.429*	1.397*	3.110*	1.402*	-1.616*	2.579*
	(0.054)	(0.071)	(0.097)	(0.183)	(0.751)	(0.414)	(0.356)
Bean vs. None	1.038*	1.039*	1.039*	1.682*	1.665*	0.517*	2.298*
	(0.055)	(0.055)	(0.055)	(0.134)	(0.387)	(0.109)	(0.317)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses; *U*(*H*)-*U*(*NH*) is relative preference for hormone added product over NAH product.

Table 2.1. Parameter Estimates by Utility Model and Estimation Approach (Continued)

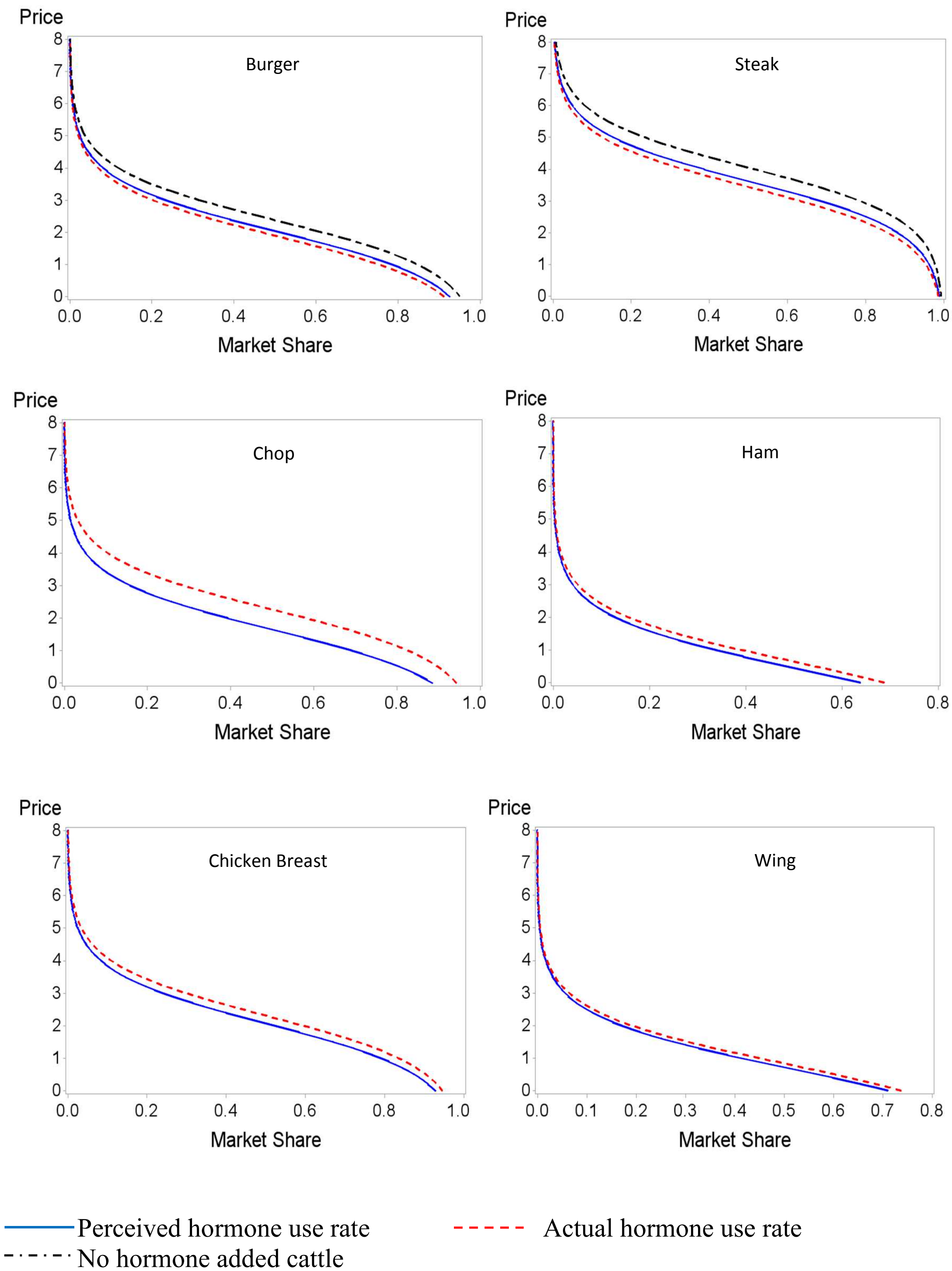
Parameters (Utilities)	Conventional Model (Conditional Logit Model)	Random Expected Utility Model (Conditional Logit Model)	Modified Random Expected Utility Model				
			Conditional Logit Model	Latent Class Model			
				Class 1 "Steak Lovers"	Class 2 "NAH Steak Lovers"	Class 3 "Vegetable Lovers"	Class 4 "Product Insensitive"
Pasta vs. None	1.567* (0.069)	1.568* (0.069)	1.568* (0.069)	3.778* (0.172)	3.352* (0.354)	0.430* (0.184)	2.322* (0.321)
U(*H*)-*U*(*NH*)							
U(*H*) (burger) - *U*(*NH*) (burger)			-0.470* (0.130)	-0.667* (0.328)	0.159 (0.647)	-0.908 (0.782)	0.069 (0.249)
U(*H*)) (steak) - *U*(*NH*) (steak)			-0.554* (0.145)	-0.836* (0.495)	-1.319* (0.654)	-0.434 (0.784)	0.048 (0.223)
U(*H*) (chop) - *U*(*NH*) (chop)			-0.572* (0.147)	-1.369* (0.413)	-0.670 (0.604)	-2.920* (0.879)	0.578* (0.281)
U(*H*) (ham) - *U*(*NH*) (ham)			-0.125 (0.170)	-0.409 (0.354)	0.718 (1.128)	-1.726 (1.097)	0.608* (0.277)
U(*H*) (breast) - *U*(*NH*) (breast)			-0.452* (0.101)	-0.515* (0.258)	-0.556 (0.374)	-0.134 (0.367)	-0.080 (0.256)
U(*H*) (wing) - *U*(*NH*) (wing)			-0.386* (0.141)	-0.242 (0.258)	-0.848 (1.146)	-1.175 (0.715)	0.082 (0.310)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses; *U*(*H*)-*U*(*NH*) is relative preference for hormone added product over NAH product.

Table 2.1. Parameter Estimates by Utility Model and Estimation Approach (Continued)

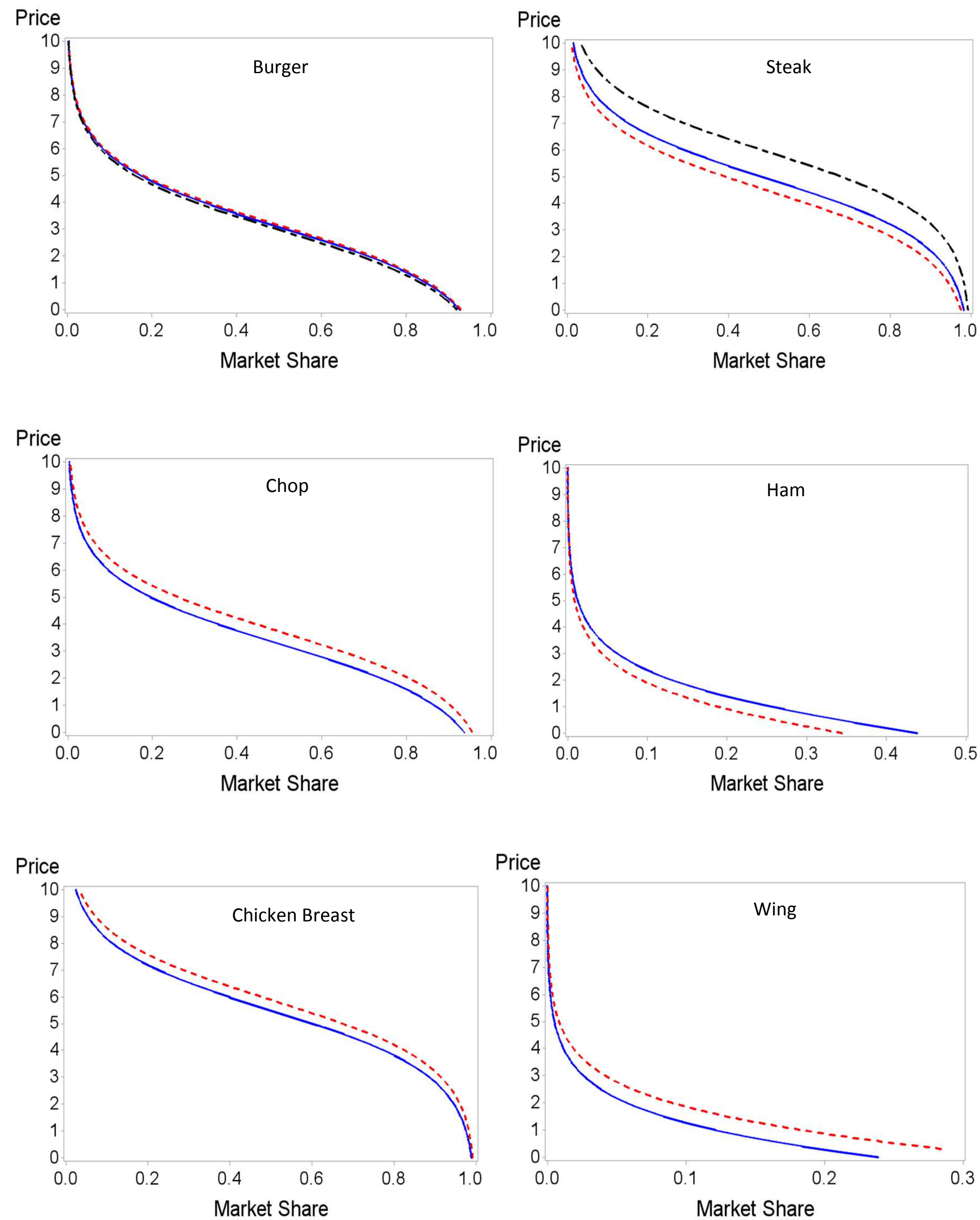
Parameters (Utilities)	Conventional Model (Conditional Logit Model)	Random Expected Utility Model (Conditional Logit Model)	Modified Random Expected Utility Model				
			Conditional Logit Model	Latent Class Model			
				Class 1 "Steak Lovers"	Class 2 "NAH Steak Lovers"	Class 3 "Vegetable Lovers"	Class 4 "Product Insensitive"
Class prob				0.331*	0.202*	0.122*	0.345*
-2 Log L	35820.633	35788.002	35781.998	31401.643			

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses; *U*(*H*)-*U*(*NH*) is relative preference for hormone added product over NAH product.



Note: Market share is among the 9 options in our choice experiment.

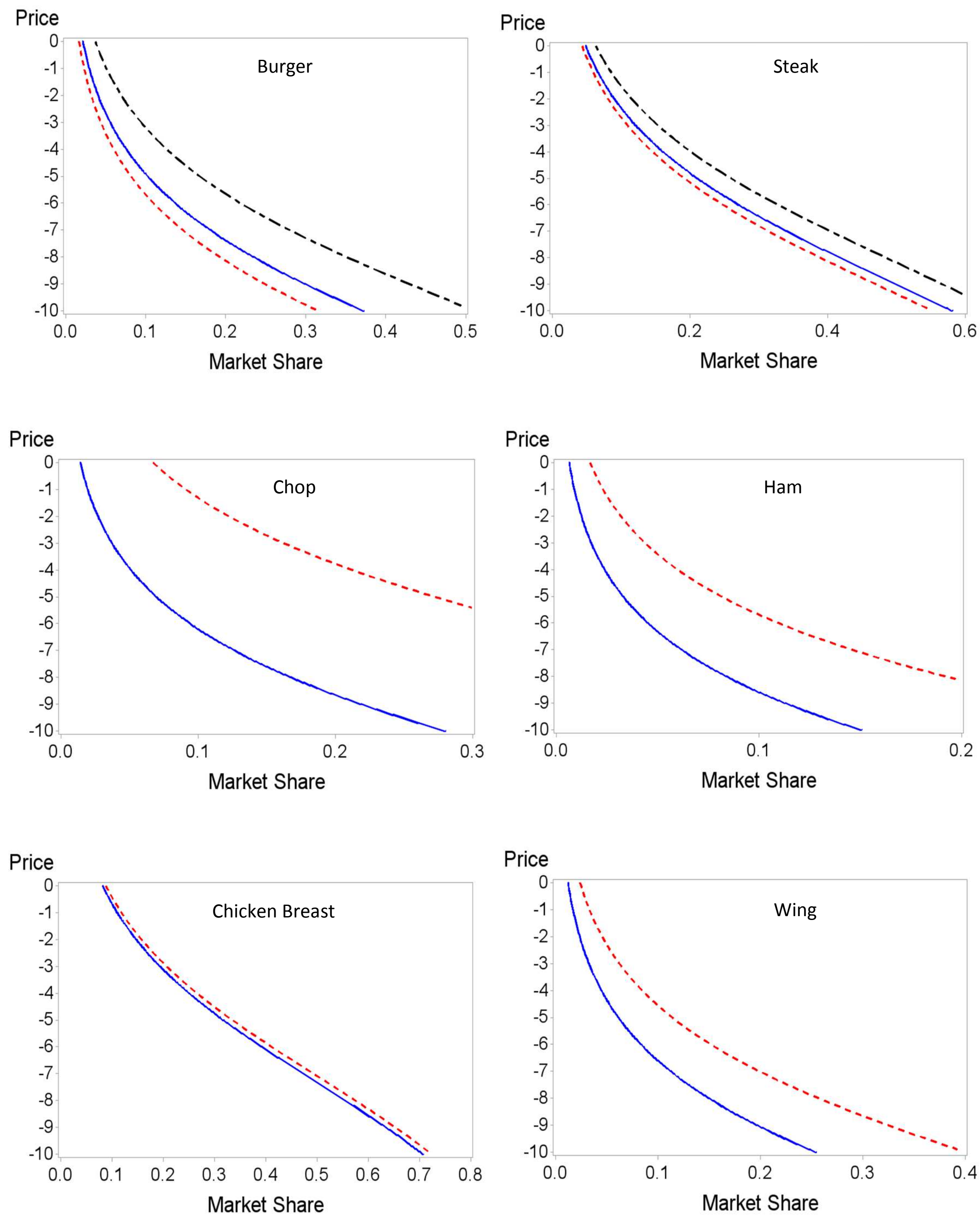
Figure 2.5. Meat product demand under different hormone use scenarios for “Steak Lovers”



Perceived hormone use rate Actual hormone use rate
No hormone added cattle

Note: Market share is among the 9 options in our choice experiment.

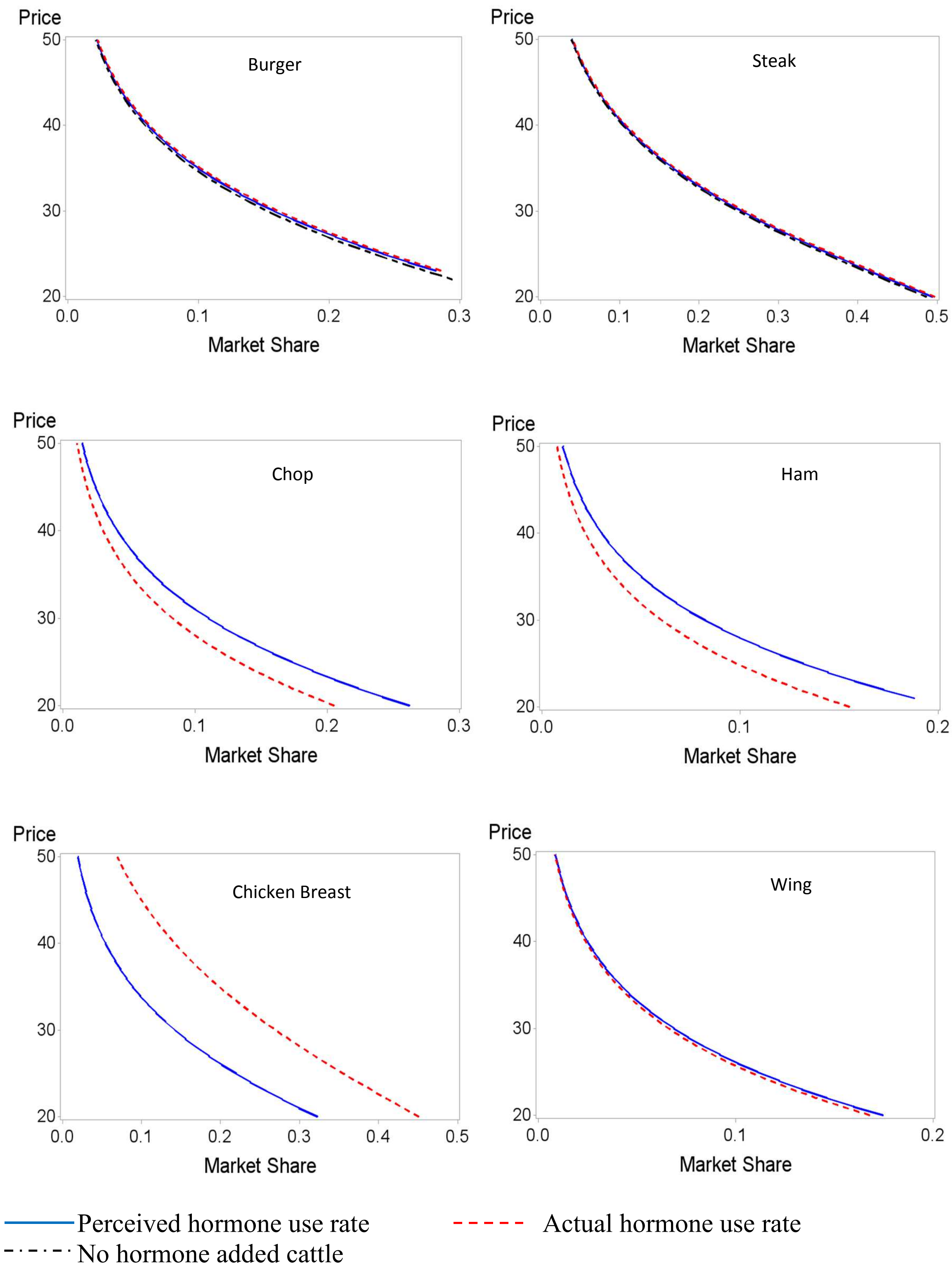
Figure 2.6. Meat product demand under different hormone use scenarios for “NAH Steak Lovers”



Perceived hormone use rate
Actual hormone use rate
No hormone added cattle

Note: Market share is among the 9 options in our choice experiment.

Figure 2.7. Meat product demand under different hormone use scenarios for "Vegetable Lovers"



Note: Market share is among the 9 options in our choice experiment.

Figure 2.8. Meat product demand under different hormone use scenarios for "Product Insensitive" group

Table 2.2. Willingness-to-Pay for Unlabeled Meat Products across Selected Hormone Use Rate

Meat Type	Hormone Use Rate		Class 1 Steak Lovers	Class 2 NAH Steak Lovers	Class 3 Vegetable Lovers	Class 4 Product Insensitive
Burger	Perceived	0.62	3.72	5.63	-5.27	33.88
	Actual	0.9	3.57	5.68	-6.04	34.07
	NAH	0	4.06	5.51	-3.56	33.48
Steak	Perceived	0.62	5.31	7.45	-2.68	39.56
	Actual	0.9	5.12	7.00	-3.05	39.69
	NAH	0	5.73	8.45	-1.86	39.28
Pork chop	Perceived	0.55	3.33	5.81	-6.55	29.94
	Actual	0	3.93	6.26	-1.67	26.91
Ham	Perceived	0.55	2.14	2.23	-8.94	26.86
	Actual	0	2.32	1.75	-6.05	23.68
Chicken breast	Perceived	0.57	3.75	8.04	-1.00	32.72
	Actual	0	3.99	8.43	-0.77	33.15
Chicken wing	Perceived	0.57	2.40	1.12	-6.95	25.01
	Actual	0	2.51	1.71	-4.91	24.56
Class probability			0.331	0.202	0.122	0.345

Note: WTP vs. None ($/lb.)

Table 2.3. Wiliness-to-Pay Premiums for Meat Products Labeled with No Added Hormones

Meat Product	WTP Premiums ($/lb.) (Mean)	S.D.	Max	Min
Steak	2.151	1.698	5	0
Hamburger	1.719	1.402	5	0
Pork Chop	1.680	1.438	5	0
Ham	1.362	1.366	5	0
Chicken breast	1.759	1.402	5	0
Chicken wing	1.294	1.260	5	0

Table 2.4. Comparison of Willingness-to-Pay Premiums for Meat Products with Label No Added Hormones using the Tobit Method

Variable	Model 1		Model 2		Model 3	
Intercept	1.113*	(0.063)	0.975*	(0.155)	1.182*	(0.357)
Hormone use rate	0.333*	(0.074)	0.319*	(0.072)	-0.051	-0.051
Meat types (vs. Wing)						
Steak	0.908*	(0.066)	0.904*	(0.063)	0.912*	(0.063)
Hamburger	0.418*	(0.066)	0.418*	(0.063)	0.426*	(0.062)
Pork chop	0.402*	(0.066)	0.401*	(0.063)	0.407*	(0.062)
Ham	0.081	(0.066)	0.080	(0.063)	0.085	(0.062)
Chicken breast	0.475*	(0.066)	0.475*	(0.063)	0.474*	(0.062)
Demographics						
Female vs. male			0.176*	(0.039)	0.042	(0.095)
Farm experience			0.218*	(0.057)	-0.354*	(0.146)
Children presence			0.337*	(0.047)	0.713*	(0.122)
Age vs. 75 years or older						
18-24 years			0.215*	(0.115)	0.564*	(0.268)
25-34 years			0.408*	(0.111)	0.693*	(0.257)
35-44 years			0.061	(0.114)	0.390	(0.264)
45-54 years			-0.204*	(0.109)	0.361	(0.249)
55-64 years			-0.368*	(0.110)	0.234	(0.257)
65-74 years			-0.409*	(0.111)	0.171	(0.256)
Education vs. Master or professional degree						
Up to high school			0.109*	(0.062)	0.003	(0.149)
Some college			-0.116*	(0.060)	-0.137	(0.148)
4-year college degree			0.107*	(0.054)	0.239*	(0.143)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 2.4. Comparison of Willingness-to-Pay Premiums for Meat Products with Label No Added Hormones using the Tobit Method (Continued)

Variable	Model 1		Model 2		Model 3	
Income vs. more than $160K						
Less than $20k			-0.296*	(0.082)	-0.350*	(0.209)
$20k-$39k			-0.173*	(0.083)	-0.564*	(0.212)
$40k-$59k			-0.212*	(0.086)	-0.818*	(0.227)
$60k-$79k			-0.197*	(0.079)	-0.799*	(0.208)
$80k-$99k			-0.189*	(0.079)	-0.355	(0.220)
$100k-$119k			-0.171*	(0.085)	-0.358	(0.234)
$120k-$139k			-0.332*	(0.094)	-0.392	(0.267)
$140k-$159k			0.192*	(0.093)	-0.921*	(0.228)
Regions vs. Plains						
Far west			0.055	(0.091)	-0.480*	(0.231)
Great Lakes			0.136	(0.093)	-0.250	(0.234)
Mideast			0.058	(0.088)	-0.032	(0.222)
New England			-0.190*	(0.111)	-0.056	(0.288)
Rocky Mountain			-0.004	(0.134)	0.216	(0.342)
Southeast			0.232*	(0.086)	-0.200	(0.219)
Southwest			0.063	(0.101)	-0.018	(0.256)
Interaction: hormone use rate* demographics						
Female					0.218	(0.152)
Farm experience					0.973*	(0.227)
Children presence					-0.628*	(0.191)
18-24 years					-0.587	(0.411)
25-34 years					-0.470	(0.396)
35-44 years					-0.609	(0.402)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 2.4. Comparison of Willingness-to-Pay Premiums for Meat Products with Label No Added Hormones using the Tobit Method (Continued)

Variable	Model 1		Model 2		Model 3	
45-54 years					-0.969*	(0.382)
55-64 years					-1.060*	(0.391)
65-74 years					-0.976*	(0.391)
Up to high school					0.180	(0.236)
Some college					0.050	(0.234)
4-year college degree					-0.238	(0.220)
Less than $20k					0.035	(0.325)
$20k-$39k					0.630*	(0.327)
$40k-$59k					1.017*	(0.349)
$60k-$79k					0.985*	(0.316)
$80k-$99k					0.257	(0.332)
$100k-$119k					0.256	(0.370)
$120k-$139k					0.116	(0.401)
$140k-$159k					1.969*	(0.352)
Far west					0.947*	(0.376)
Great Lakes					0.749*	(0.384)
Mideast					0.163	(0.363)
New England					-1.114	(0.447)
Rocky Mountain					-0.381	(0.557)
Southeast					0.825*	(0.357)
Southwest					0.210	(0.410)
Log Likelihood	-11061		-10780		-10708	
AIC	22137		21630		21541	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

CHAPTER III

IMPACT OF INFORMATION ON CONSUMER MEAT PREFERENCES

Introduction

The rise of food label claims has caused food choices to become complex decisions. Consumers typically consider brand, price, shelf life, and nutrition when they purchase food products. Food production practices become a new set of attributes for consumer consideration. For many consumers, buying chicken becomes more complex than deciding whether to buy chicken breast or chicken wings at a suitable price and expiration date. They are concerned about how chickens were raised, including production practices related to feed content, growth hormones and antibiotics for example. Food labels help provide answers. However, sometimes food labels may confusion. For example, 'no added hormones' (NAH) labels on pork or chicken products may lead consumers to believe that hormones are used in pork or chicken production, though the use of added hormones is not allowed in the U.S. In Chapter II, results indicate that consumers' average perceived hormone use rate is 62% for cattle, 55% for hogs, and 57% for chickens, while the actual hormone use rate in cattle is more than 90% and there is no hormone use in swine or chicken production. This suggest that most consumers are not well-informed regarding actual use of hormones in meat production.

Consumers often place premiums on label claims related to food production methods. Extensive research on consumer preferences and willingness-to-pay (WTP) for products with different label claims has been conducted. The review of Yiridoe et al. (2005) addressed consumer perceptions and preference for organic labels. Norwood and Lusk (2011) presented an economic analysis of labels related to animal welfare. In Chapter II, we found that consumers are willing to pay premiums on meat products labeled “no added hormones” (NAH), including pork and chicken products, though all pork and chicken products are produced with NAH.

Given that most consumers have little direct involvement in food production, many food choices are likely made with inaccurate beliefs regarding production claims, particularly for credence attributes where the attribute is not visibly observed. Consumer beliefs about food attributes play an important role in their food choices. If consumers have factual information about food production to inform their perception, they may make different choices about products and WTP, potentially increasing utility.

Information related to food product attributes has influence on consumer food choice decisions. For example, information that red meat may increase cholesterol levels resulted in changes in meat demand. Adhikari et al. (2006) that found cholesterol information reduced U.S. demand for beef and pork and increased chicken demand. Rickertsen, Kristofersson, and Lothe (2003) concluded that chicken demand in Finland, Norway, and Sweden increased as information about cholesterol was more widely disseminated. So, actual hormone use information given to consumers may change consumer demand for meat products.

Economists have frequently studied the impact of hormone use on consumer preference for food products. For example, Lusk, Roosen and Fox (2003) compared consumer valuation of steaks from cattle produced with and without added hormones. Ellison, Brooks, and Mieno (2017) examined the impact of labels indicating animals were not administered growth hormones on consumer food choices. However, those studies do not account for consumer perceptions of hormone use in meat production. In chapter II, we find that consumer perceptions of hormone use in meat production affect their preference and WTP for meat products. Therefore, if consumers are given the actual hormone use information, will their preference for meat products change?

The purpose of this paper is to identify the impact of information on consumer preferences for selected meat products. Specifically, we assess whether consumer perception of hormone use affects choices for unlabeled meat products and whether preference for unlabeled meat products changes after receiving the factual information regarding hormone use in livestock and poultry production. We also identify whether information impacts WTP premiums for meat products labeled as NAH.

Data

Data were collected from survey questions in Oklahoma State University's monthly Food Demand Survey in March 2018. The Food Demand Survey is a national wide online survey conducted monthly by Oklahoma State University (Lusk, 2017). The monthly survey contains a standard set of questions regarding consumer preferences and WTP for a set of meat products, including choice questions (Figure 2.2), as well as questions designed to gauge the degree of consumer concerns on various topics. Questions (Figure 2.1, 2.3) specific to this survey were appended to this standard monthly survey. Each month over 1,000 completed surveys are obtained. The sample size yields a 3% sampling error with 95% confidence interval for dichotomous choice questions. A total of 1,026 consumers responded to the March 2018 survey.

Subjects were asked to indicate their perception of the prevalence of hormone use in production of different livestock species, including beef cattle, pigs, and broiler chickens (Figure 2.1). They were also asked to make 9 discrete choices (Figure 2.2). In each choice, subjects chose from 8 types of food products including hamburger, steak, pork chop, ham, chicken breast, chicken wings, bean, pasta and a “no purchase” option. Prices of each food product varied across the 9 choices. The WTP premiums questions asked willingness-to-pay premiums for meat products labeled as NAH with the highest premium payment set to five dollars per pound (Figure 2.3). Subjects then were given factual information about hormone use rates in meat production across cattle, hogs and chickens:

> “Approximately 90 percent of all U.S. feedlot cattle are injected with hormones to improve growth rates and feed efficiency. Currently federal regulations do not allow the use of growth hormones in chicken or hog production.”

After reading the information statement, subjects were asked to repeat choice questions and WTP premiums questions regarding NAH labeled products.

Methods

Consumer perception of hormone use rates is obtained from the survey question in Figure 2.1. Standard t-tests are used to examine whether consumer perception of hormone use rates in meat production across cattle, hogs and chicken differ from actual use.

The choice experiment data from choice questions (Figure 2.2) with perceived hormone use is analyzed using a random expected utility model (Savage, 1954)

$$EU_{ij} = \gamma_j + B_{ij}U(H)_j - \alpha Price_j \quad (1)$$

where EU_{ij} is i^{th} subject's expected utility of product j, $Price_j$ is the price of product j, and γ_j is the fixed effect of product j , B_{ij} is subject i's belief that product j is hormone added, and $U(H)_j$ is relative preference for hormone added product j over NAH product j. We allow relative preferences for NAH meat products to differ. The preference for NAH, $U(NH)$, has implicitly been normalized to zero. The result is that $U(H)$ represents the difference in utilities for the hormone-added attribute versus the NAH attribute of a product. $U(H)$ is expected, though not restricted, to be non-positive. This allows isolation of the relative contributions of the hormone-added attribute from overall preference for product j. A traditional conditional logit model (McFadden, 1973) is used to estimate the expected utility model in Equation 1.

A primary objective is to examine whether consumer preference for meat products changes after receiving factual hormone use information. This is accomplished using choice experiment data both before and after the actual hormone use information statement is presented. The responses are analyzed using a random utility model (McFadden, 1973)

$$EU_{ij} = \gamma_j - \alpha Price_j + \delta_j I_i \quad (2)$$

where EU_{ij} is the i^{th} subject's expected utility of product j, $Price_j$ is the price of product j, and γ_j is the fixed effect of product j, I_i is an indicator of whether the subject receives factual hormone use information. Traditional conditional logit model and latent class model (LCM) (Boxall and Adamowicz, 2002) are both used to estimate the random utility model with factual hormone use information in Equation 2. The traditional conditional logit model assumes that all individuals in the sample have the same level of preference for meat products and utility of information. To overcome this weakness, the LCM is applied. Since the LCM models with different number of latent classes, we select the model that yields the smallest AIC number where each class represents at least 10% of the sample.

The demand for meat product j given a particular choice set J is

$$D_j = \frac{e^{EU_j}}{\sum_{k=1}^{J} e^{EU_k}} \tag{4}$$

where D_j is demand (or market share) for meat product j, EU_j is expected utility of product j, EU_k is expected utility of k^{th} product in meat choice set J, and EU_j and D_j are positively related.

Willingness-to-pay premiums for meat products labeled NAH from WTP premiums questions (Figure 2.3) are analyzed to see whether WTP premiums are affected by factual information factor. The Tobit model is chosen for estimation since maximum WTP premiums are censored with an upper bound of $5/lb.

Results

The average perceived hormone use rate is approximately 60% for cattle, 56% for hogs, and 58% for chickens (Figure 3.1), similar to the results in Chapter 2 (Chapter 2 indicates that consumers' average perceived hormone use rate is 62% for cattle, 55% for hogs, and 57% for chickens). Based on standard t-tests, consumer perceived hormone use rates are significantly different from actual hormone use rates at the 99% level for each specie. Survey participants, on average, ranked beef cattle the highest for hormone use among beef cattle, pigs, and broiler chickens. Less than 2% of subjects correctly answered that 0% of pigs and broilers are given added hormones, indicating that 98% of respondents incorrectly think that hormones are used at least to some extent in pork and chicken production. As in the previous study (Chapter 2), consumers tend to underestimate hormone use in beef production and overestimate hormone use in pork and poultry production.

Table 3.1 reports results for the random expected utility model incorporating beliefs about hormone use and identification of preferences for the selected meat products included in the survey (Equation 1). Consumers derive the highest utility from steak and the least utility from chicken wings. Marginal utilities of hormone use rate for individual meat products are all negative, indicating that a consumer is less likely to choose the product if he believes it is hormone added. The marginal utility of hormone use rate is highest for burger (1.029) and lowest for chicken breast (0.638).

Table 3.2 reports willingness-to-pay (WTP) estimates for meat products as compared to “no purchase” in our choice experiment. WTP estimates are higher for burger and steak with perceived hormone use (60%) in beef than with actual hormone use (90%) and highest for NAH burger and NAH steak. Consumers would pay $0.60/lb. and $0.40/lb. less for burger and steak, respectively, if they knew the actual hormone use rate in cattle production. WTP for NAH burger and NAH steak are $1.20/lb. and $0.81/lb. higher than unlabeled burger and steak, respectively, and would be $1.80/lb. and $1.21 more than unlabeled burger and steak, respectively, if consumer perceptions equated with the actual hormone use rate in cattle production. The demand for NAH burger and NAH steak would be larger if consumers knew the actual hormone use rate in cattle production. Consumers would pay \$0.82/lb. and \$1.05/lb. more for pork chops and ham, respectively, if their perceptions equated with the actual hormone use rate in swine production. They would also pay \$0.72/lb. and \$0.87/lb. more for chicken breast and wings, respectively, if their perceptions equated with the actual hormone use rate in chicken production.

Table 3.3 reports results from the random utility model, including the information effect (Equation 2). The results of conditional logit model (Table 3.3) indicate that consumer utility for factual hormone use information is negative for burger and steak, but positive for pork chops, ham, chicken breast and wings. That is, the utility derived from burger and steak decreases after consumers read the information about actual hormone use in different livestock species, while the utility derived from pork chops, ham, chicken breast and wings increases after reading the same information.

The results of the LCM (Table 3.3) indicate that the choice experiment data can be divided into three classes: Price Sensitive, White Meat Lovers and Product Indifference. The probability that a randomly chosen respondent belongs to a given class is 50.4%, 17%, and 32.6%, respectively. The first latent class can be characterized as "Price Sensitive", due to a relatively high price coefficient value relative to price coefficients in the other two classes. Consumers in this group (50.4% of sample population) are relatively more sensitive to price, sacrificing more utility compared to the two other classes, when price increases. The group's highest utility is from steak (5.051). Price Sensitive consumers have the largest utility decrease for steak (-0.969) after receiving actual hormone use information. Utility also decreases for burger (-0.674) after receiving actual hormone use information. Price Sensitive group's utility from ham

(1.533) is lower than for pork chops (2.96), but the utility increase for ham (0.154) is higher than for pork chops (0.126) after receiving the actual hormone use information. Similarly, the utility for chicken wings (1.293) is higher than for chicken breast (3.813), but the utility increase for chicken wings (0.551) is higher than chicken breast (-0.057). In general, Price Sensitive group's utility from expensive meat products (e.g. steak, pork chop, chicken breast) is higher than for less expensive meat products (e.g. burger, ham, chicken wings). Consumers in this group prefer expensive meat products. When presented with actual hormone use information, their utility decreases more for the expensive beef product than for the relatively less expensive beef product, but utility increases more for less expensive pork and poultry products. This group's demand for steak and burger decrease but their demand for ham and chicken wing increases after receiving actual hormone use information in meat production.

In the second class, nick named "White Meat Lovers", the coefficient for chicken breast is the highest. Consumers in this group (17% of sample population) are highly likely to choose chicken breast among the 9 products offered, and the utility from chicken breast, beans and pasta are relatively higher than other products. Knowledge of actual hormone use decreases their utility for steak and increases utility for ham, with demand for steak and ham following a similar pattern.

In the third class, "Product Indifferent", coefficients differ little across products. Consumers in this group, representing 32.6% of sample population, may be characterized as shoppers with little difference in preferences for meat products. Information increases their utility for pork chops but decreases utility for chicken wings, with the same demand response for pork chops and chicken wings.

Generally, utility decreases for beef products and increases for pork products in all three classes after receiving actual hormone use information. For more than 67% of the consumers (Class 1 and 2), utility for chicken wings increases after they receiving the information. The results taken together suggest that demand for meat products included in the consumers' choice set is affected by information about actual hormone use in different livestock species. After the hormone use information is provided, demand for beef products decreases across classes, while demand for pork products increases. Chicken wings demand increases post-information for consumers in Class One and Two (67% of sample population), with little change for the Product Indifferent group.

Table 3.4 reports changes in WTP for meat products post-information. For all consumers, assuming homogeneity of preferences, WTP decreases for beef products and increases for pork and poultry products after receiving hormone use information. For consumers in the "Price Sensitive" group, WTP decreases by $0.85/lb. and $0.59/lb. for steak and burger, respectively, but increases by $0.14/lb. and $0.49/lb. for ham and chicken wings, respectively, after receiving information. Consumers in "White Meat Lovers" group are willing to pay $4.44/lb. less for steak but $3.27/lb. more for ham, when given hormone use information. Consumers in the "Product Indifferent" class are willing to pay $1.18/lb. more for pork chops when informed that no added hormones are used in pork production. Interestingly, WTP for chicken wings decreases after this group receives information that no hormones are used in chicken production. In general, nearly all consumers will pay less for beef products after receiving hormone use information, but WTP are more for pork chops. More than 67% of consumers in the study are willing to pay more for ham when information that there is no hormone added in pork production is received. After consumers receive the information that no hormone is used in chicken production, more than 50% of the consumers are willing to pay more for chicken wings, however, WTP change post-information for chicken breast is little for all groups.

The survey also asked subjects about WTP premiums for NAH labeled meat products before and after receiving hormone use information. Consumers indicated that they are willing to pay more for meat products labeled NAH both pre- and post-information, as seen in the mean WTP values reported in Table 3.5. Table 3.6 presents results from Tobit model implemented to analyze WTP premiums for meat products labeled NAH. Consumers are willing to pay the highest premiums for NAH labeled steak and the lowest premiums for NAH labeled chicken wings. WTP premiums for NAH labeled high value cuts are higher within species than for NAH labeled lower value cuts. In addition, WTP premiums for NAH labeled meat products, including burger, steak, ham, chicken wings are not affected by the information. However, WTP premiums for NAH labeled pork chops and chicken wings become lower post-information.

Figure 3.2 presents the distribution of willingness-to-pay premiums for NAH labeled meat products. The distributions of WTP premiums for NAH labeled burger and steak are similar pre- and post-information. More than 80% of the consumers will pay more for NAH labeled burger and steak. Around 13% of the consumers are willing to pay premiums for NAH labeled steak as high as $5/lb. or more. About 23% of the consumers will not pay more for NAH labeled pork chops pre-information. But the percentage of consumers who will not pay more for NAH labeled pork chops increases to 34% after receiving actual hormone use information. The percentages of consumers who will not pay more for NAH labeled ham, chicken breast and chicken wings also increase post-information. Therefore, if consumers are given the information that no hormones are used in pork and chicken production, WTP premiums for NAH labeled pork and chicken products decrease, and 30%-40% of the consumers will not pay more for NAH labeled pork and chicken products.

Conclusions

This chapter indicates that consumers' average perceived hormone use rate in meat animal production is 60% for cattle, 56% for hogs, and 58% for chicken, while in reality, more 90% of cattle are produced using added hormones and there is no hormone use in pork and chicken production. Meat demand is affected by consumers' misbeliefs about hormone use in meat production. The demand (predicted market share among the 9 food products in the survey) for NAH burger and NAH steak would be larger if consumers' perception of hormone use in cattle production was correct. If consumers correctly perceived NAH in pork or chicken production, the demand for pork and chicken products would be larger.

Results indicate that information about actual hormone use in meat production can impact meat demand. We examine how provided actual hormone use information affects consumer choices for various meat products. Results reveal that utility for unlabeled beef products is lower after consumers learn that more than 90% of cattle received added hormones, while utility for unlabeled pork and chicken products is higher after consumers learn that hormones are not used in pork and chicken production. Demand for beef products decreases while demand for pork and chicken products increases after consumers receive actual hormone use information.

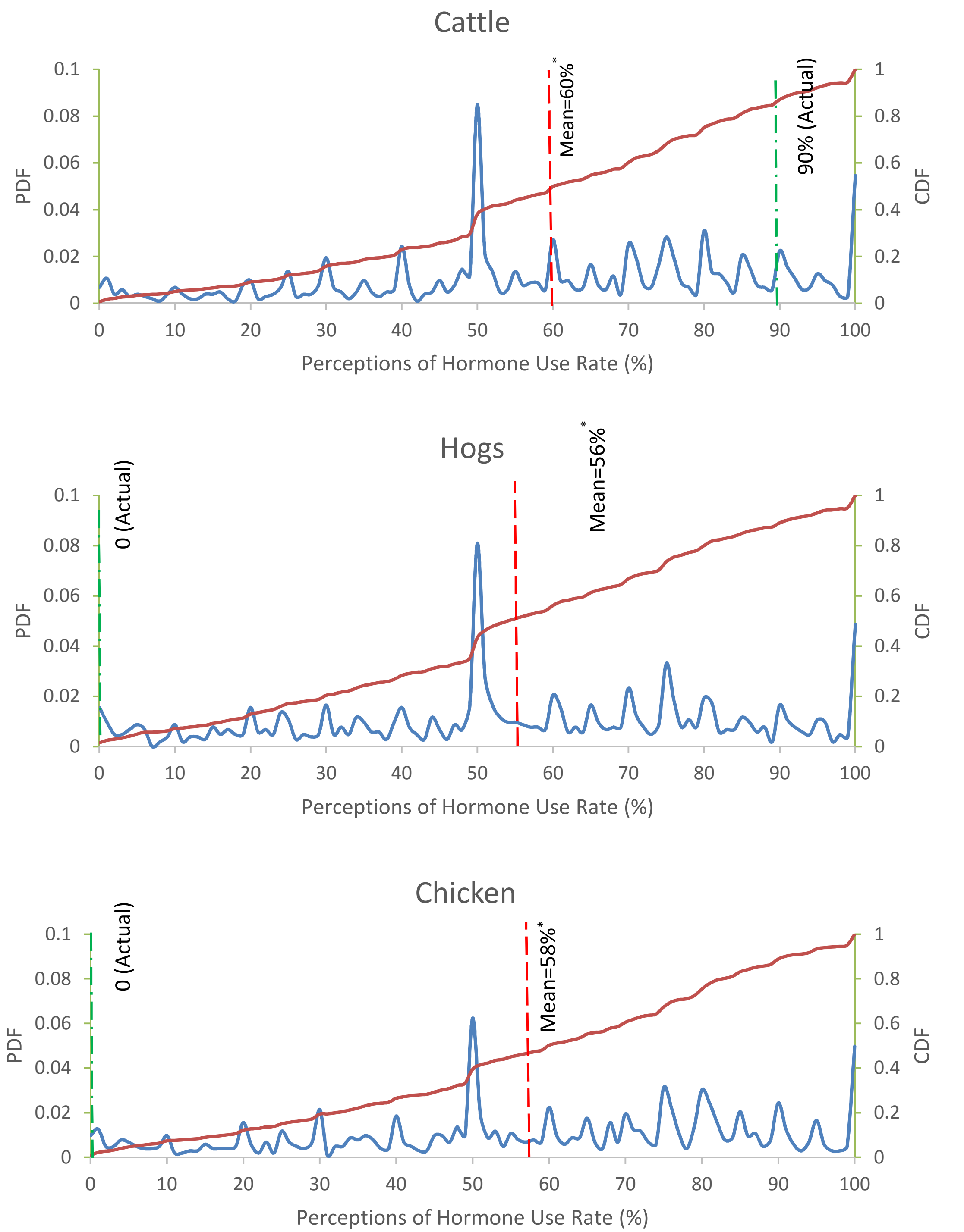
Consumers are willing to pay more for NAH labeled meat products, relative to unlabeled products, both before and after receiving actual hormone use information. However, WTP premiums for NAH labeled pork chops and chicken breast become lower after consumers are provided with information that no hormones are used in pork and chicken production.

The NAH labels may lead consumers to believe that NAH labeled meat products are different or healthier than similar unlabeled products, while in reality, all poultry and pork products are NAH. In fact, the claim "no added hormones" cannot be used on the labels of pork or poultry unless it is followed by a statement that says "Federal regulations prohibit the use of hormones." (USDA, 2015). However, manufacturers may shrink, minimize, or obscure this statement of clarification, so it is hard for consumers to notice such clarification. But our study indicates such clarification influence consumer meat preference. Therefore, regulating labeling claims to deliver correct information effectively to consumers is important.

Educating consumers with actual information about food production will better aid consumers satisfy their needs. If consumers are given actual food production information, the feedback of demand for food attributes will provide producers more actual information to identify consumer valuable attributes. It is important for producers to market their products and anticipate sales.

This study presents the distribution of WTP premiums for NAH labeled meat products (Figure 3.2). The percentage of subjects whose WTP premiums are higher, i.e. larger than $3/lb., are similar pre- and post-information across different meat products. This represents a group of consumers who are willing to pay premiums for NAH labeled meat products despite of receiving factual hormone use information. What are the demographics for consumers whose WTP premiums are high? What are the demographics for consumers who are still paying more after receiving factual production information? Analyzing the demographic effects on WTP changes pre- and post-information would provide important information to the industry.

In the Food Demand Survey, March 2018, the hormone use factual information was posted without reference to the information source. Subjects may perceive the information statement was made up or was less than credible. Information sources can play an important role as consumers form or change their beliefs as well as when they choose food products. The credibility of production information may have a strong effect on consumer food choices. Using a more strict referenced statement in the follow-up study may provide an insight on this issue.



Cumulative distribution function (CDF Probability density function (PDF)

Note: Single asterisk (*) denotes statistical significance at 1% level.

Figure 3.1. Distribution of consumer perceptions of hormone use rate in cattle, hogs and chicken

Table 3.1. Parameter Estimates from the Random Expected Utility Model (Equation 1)

Parameters (Utilities)	Random Expected Utility Model
-1 * Price	0.514*
	(0.011)
Burger vs. None	2.865*
	(0.093)
Steak vs. None	3.890*
	(0.118)
Chop vs. None	2.160*
	(0.105)
Ham vs. None	1.602*
	(0.102)
Breast vs. None	3.178*
	(0.080)
Wing vs. None	1.555*
	(0.095)
Bean vs. None	1.055*
	(0.052)
Pasta vs. None	1.162*
	(0.069)
U(*H*) (burger)-*U*(*NH*) (burger)	-1.029*
	(0.126)
U(*H*)) (steak) –*U*(*NH*) (steak)	-0.690*
	(0.142)
U(*H*) (chop) –*U*(*NH*) (chop)	-0.759*
	(0.153)
U(*H*) (ham) –*U*(*NH*) (ham)	-0.958*
	(0.158)
U(*H*) (breast)-*U*(*NH*) (breast)	-0.638*
	(0.100)
U(*H*) (wing)-*U*(*NH*) (wing)	-0.771*
	(0.137)
-2 Log L	35599.3
AIC	35629.3

Note: Single asterisk (*) denotes variables statistical significant at 1%; Standard errors are in parentheses; U(H)-U(NH) is relative preference for hormone added product over NAH product.

Table 3.2. Willingness-to-Pay for Unlabeled Meat Products across Selected Hormone Use Rate

Meat Type	Hormone Use Rate		WTP
Burger	Perceived	0.6	4.37
	Actual	0.9	3.77
	NAH	0	5.57
Steak	Perceived	0.6	6.76
	Actual	0.9	6.36
	NAH	0	7.57
Pork chop	Perceived	0.56	3.38
	Actual	0	4.20
Ham	Perceived	0.56	2.07
	Actual	0	3.12
Chicken breast	Perceived	0.58	5.46
	Actual	0	6.18
Chicken wing	Perceived	0.58	2.16
	Actual	0	3.03

Note: WTP vs. None ($/lb.)

Table 3.3. Parameter Estimates for the Random Utility Model (Equation 2)

Parameters (Utilities)	Conditional Logit Model	Latent Class Model Class 1 Price Sensitive	Class 2 White Meat Lover	Class 3 Product Indifferent
-1 * Price	0.542*	1.134*	0.252*	0.192*
	(0.008)	(0.020)	(0.022)	(0.017)
Burger vs. None	2.296*	3.377*	0.284	3.636*
	(0.046)	(0.077)	(0.520)	(0.196)
Steak vs. None	3.590*	5.051*	0.933*	4.532*
	(0.063)	(0.161)	(0.473)	(0.212)
Chop vs. None	1.773*	2.960*	0.281	3.055*
	(0.053)	(0.090)	(0.442)	(0.206)
Ham vs. None	1.077*	1.533*	-0.288	2.741*
	(0.050)	(0.074)	(0.421)	(0.196)
Breast vs. None	2.874*	3.813*	4.093*	3.574*
	(0.041)	(0.072)	(0.192)	(0.201)
Wing vs. None	1.099*	1.293*	0.563*	2.959*
	(0.045)	(0.074)	(0.315)	(0.195)
Bean vs. None	1.069*	0.570*	3.304*	2.060*
	(0.037)	(0.059)	(0.177)	(0.188)
Pasta vs. None	1.509*	2.260*	2.854*	2.418*
	(0.049)	(0.086)	(0.194)	(0.195)
U(*I*) (burger)	-0.385*	-0.674*	-1.169	-0.046
	(0.047)	(0.088)	(0.716)	(0.118)
U(*I*) (steak)	-0.352*	-0.969*	-1.119*	-0.054
	(0.054)	(0.198)	(0.630)	(0.110)
U(*I*) (chop)	0.141*	0.126	0.624	0.226*
	(0.055)	(0.100)	(0.516)	(0.132)
U(*I*) (ham)	0.044	0.154*	0.825	-0.063
	(0.058)	(0.924)	(0.443)	(0.134)
U(*I*) (breast)	0.017	-0.057	0.018	-0.033
	(0.036)	(0.077)	(0.084)	(0.127)
U(*I*) (wing)	0.163***	0.551*	0.488	-0.553*
	(0.049)	(0.087)	(0.342)	(0.143)
Class prob		0.504*	0.170*	0.326*
		(0.014)	(0.010)	(0.013)
-2 Log L	74795.5	64151.4		
AIC	74825.5	64245.4		

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses; *U(I)* is the information effect.

Table 3.4. Changes in Willingness-to-Pay for Meat Products after Receiving Factual Hormone Use information

Meat Type	All Consumers ($/lb.)	Class 1 Price Sensitive ($/lb.)	Class 2 White Meat Lover ($/lb.)	Class 3 Product Indifferent ($/lb.)
Burger	-0.71*	-0.59*	-4.64	-0.24
Steak	-0.65*	-0.85*	-4.44*	-0.28
Pork chop	0.26*	0.11	2.48	1.18*
Ham	0.08	0.14*	3.27*	-0.33
Chicken breast	0.03	-0.05	0.07	-0.17
Chicken wing	0.30*	0.49*	1.94	-2.88*
Class probability		50.4%	17%	32.6%

Note: Single asterisk (*) denotes variables statistical significant at 10%.

Table 3.5. Wiliness-to-Pay Premiums for Meat Products Labeled "No Added Hormones"

Meat Product	WTP Before Information ($/lb.)	WTP After Information ($/lb.)
Burger	1.60	1.61
	(1.42)	(1.44)
Steak	2.09	2.00
	(1.77)	(1.74)
Pork Chop	1.56	1.41
	(1.41)	(1.45)
Ham	1.31	1.20
	(1.38)	(1.40)
Chicken breast	1.65	1.53
	(1.41)	(1.47)
Chicken wing	1.20	1.17
	(1.22)	(1.31)

Table 3.6. Willingness-to-Pay Premiums for Meat Products Labeled "No Added Hormones" using the Tobit Method

Variable	Estimate	Standard Error
Intercept	1.204^{*}	0.048
Burger	0.415^{*}	0.067
Steak	0.975^{*}	0.068
Chop	0.371^{*}	0.067
Ham	0.117^{*}	0.067
Breast	0.471^{*}	0.067
Burger*Information	0.009	0.067
Steak*Information	-0.105	0.068
Chop*Information	-0.153^{*}	0.067
Ham*Information	-0.104	0.067
Breast*Information	-0.130^{*}	0.067
Wing*Information	-0.027	0.067

Note: Single asterisk (*) denotes variables statistical significant at 10%.

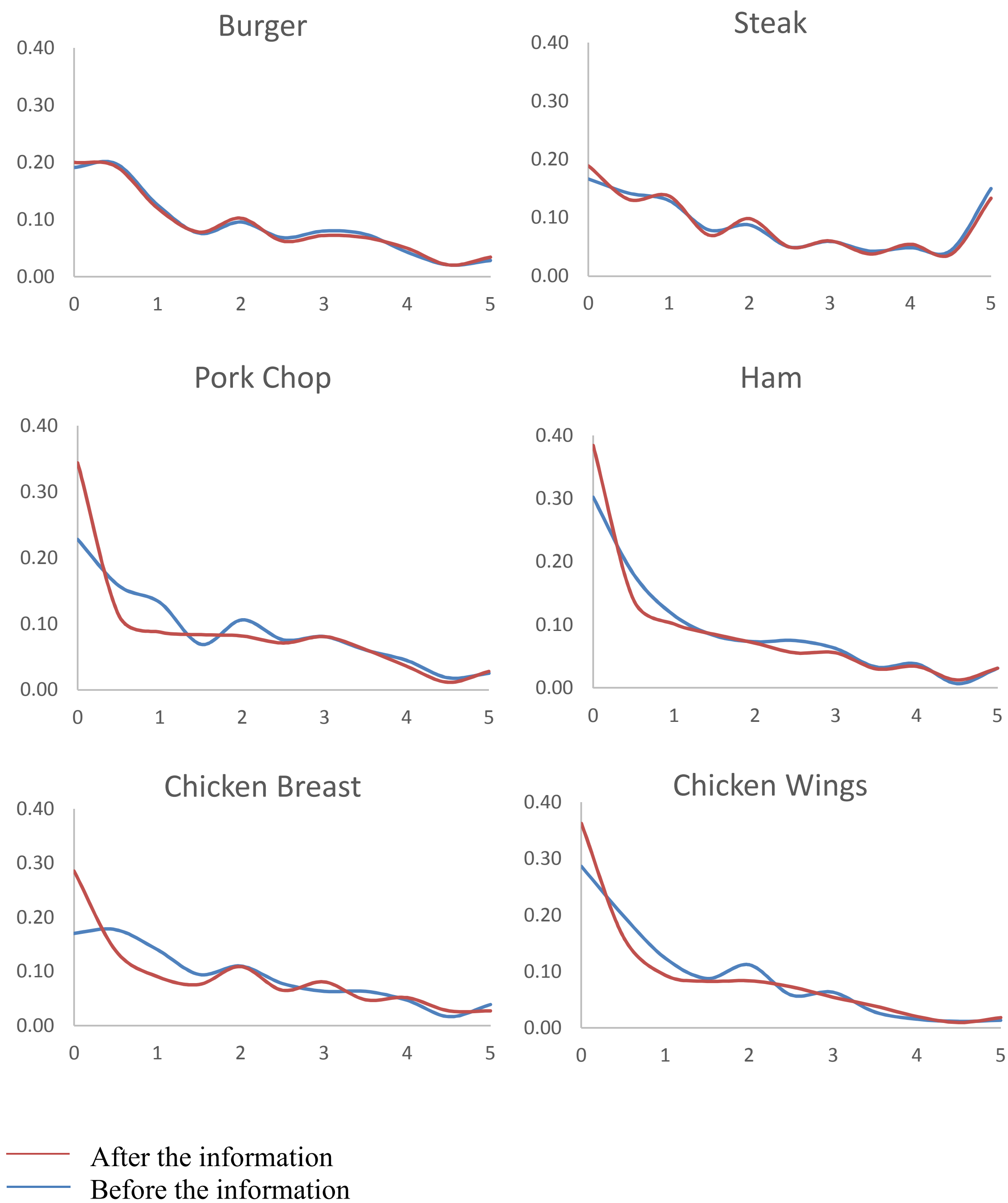


Figure 3.2. Distribution of willingness-to-pay premiums for meat products labeled "no added hormones"

CHAPTER IV

THE INFLUENCE OF RECESSION AND INCOME STRATA ON CONSUMER DEMAND FOR PROTEIN SOURCES

Introduction

The U.S. economy experienced a significant economic recession from December 2007 through June 2009 (NBER, 2012). Median household income started to fall in 2007 and did not rise again until 2012. In fact, median household income in 2015 was 1.6 percent lower than in 2007 (U.S. Census Bureau, 2016). As income changes, consumers may change expenditures across many categories including food. Protein is a crucial nutritional intake for adults and children in the United States. People consume a variety of food as protein sources including meat, eggs, dairy products and beans. Thus, consumers have multiple options to consider in rearranging their shopping basket to satisfy daily protein consumption under financial pressure. Decreasing incomes may influence consumer expenditure patterns on protein sources (Figure 4.1). However, such income may have an immediate impact or may also have a lagged effect on expenditure pattern changes for protein sources because consumer purchasing habits can change gradually and because recessions happen over time rather than at a point in time.

Consumers may choose to purchase relatively less non-meat expensive products, such as eggs and beans as protein sources instead of more expensive meat products. They may also purchase relatively inexpensive meat products as protein sources. For example, they may buy chicken instead of beef. Further, households with different incomes may have different food expenditure patterns, including protein source expenditures. Low, middle and high-income households may also vary in their expenditure responses to financial pressure, for example, in a recession period.

Most food demand studies are implemented from the perspective of food types, such as meats, vegetables and fruits, rather than nutritional categories. Demand for protein is an important nutritional category. Many food policies and food assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP), are targeted at low-income households with the intent of improving participants' nutritional status. Quantitative information on demand for protein sources across different income groups can inform public policy. Since meat, including beef, pork and poultry, is the primary protein source in the U.S., a large body of research has focused on factors that influence meat demand. This article brings a new perspective on meat demand by examining substitution among protein sources, including both meat and non-meat sources.

Financial pressure during recessionary periods can impact consumer spending patterns. However, the timing of behavioral change is not always defined by an event. Previous research often defines break dates (i.e. points of structural change) according to the event. For example, Okrent and MacEwan (2014) chose 2008, the beginning of great recession as a break date and compared the elasticities of demand for nonalcoholic beverages between pre-recession (1999-2007) and recession and post-recession periods (2008-2010). However, expenditure may not respond to a recession immediately.

The purpose of this article is to analyze whether and how consumer demand for protein sources was impacted by the Great Recession. First, we use multiple methods, including a state space model (Harvey, 1989; De Jong and Penzer, 1998) and Bai and Perron (2006) tests, to examine whether structural change in expenditure patterns on protein sources occurred. Second, we integrate that information into a Time-Varying Almost Ideal Demand System (TV-AIDS) demand system for protein sources including beef, pork, poultry, fish and seafood, eggs, dairy products, dried beans, and an "other meat" composite. Finally, we examine changes in elasticities of demand for protein sources across different quintile income levels.

Background

In the food demand literature, most studies examine demand from the perspective of food types, such as food away home, food at home, meats, vegetables and fruits. Okrent and Alston (2011) used Barten's synthetic demand system to estimate demand for FAFH, cereals and bakery products, meat, eggs, dairy, fruits and vegetables, other foods, nonalcoholic beverages, alcoholic beverages and nonfood using 1960-2009 annual data. Piggott et al. (2007) examined meat demand in a generalized Almost Ideal Demand System (AIDS) using quarterly data from 1982-2005. Adhikari et al. (2007) estimated demand for vegetables with annual data from 1980-2003 using linearized AIDS (LAIDS). However, articles examining food demand from the perspective of nutritional categories, such as protein sources, is scarce. Zhen et al. (2013) modeled household preferences for foods and beverages with an Exact Affine Stone Index (EASI) demand system using household food purchase data from the 2006 Nielsen Home scan panel. Their study focused on nutrient aspects including calories, fat and sodium. Mejia and Peel (2012) do include beans based on cultural indications when they estimate demand by Mexican households for beans and meat products (beef, fish, pork, chicken and processed meats). We expand this concept by estimating demand for broader protein categories including beef, pork, poultry, fish and seafood, eggs, dairy products, dried beans, and an "other meat" composite.

Park et al. (1996), Raper, Wanzala, and Nayga (2002), Huang and Lin (2000), and Davis, Yen and Lin (2007) presented elasticities of demand for food by income group. Park et al. (1996) and Raper, Wanzala, and Nayga (2002) estimated elasticities of demand for foods by "poverty" and "nonpoverty" groups using a linear expenditure system (LES) with cross sectional data. Huang and Lin (2000) estimated food demand elasticities for low-, middle- and high-income levels in the U.S. using cross sectional data by LAIDS. Davis, Yen and Lin (2007) presented elasticities of demand for meats by high income and low income group using cross section data by indirect translog (ITL) demand model. This article estimates elasticities of demand for protein sources at different quintile income levels across time.

Meat, as an important protein resource, is a common food at the U.S. dining table. American consumption patterns for meat have changed over the past few decades. Before the late 1970s, growth in the U.S. economy and rising consumer incomes supported consistent beef demand growth. About 1980, however, domestic retail beef demand weakened, declining every year through 1998. From the late 1990s through 2004, retail beef demand increased, but it weakened again from 2005 through 2008 (Tonsor, Mintert, and Schroeder, 2009). A large body of research has focused on factors for changes in meat demand, such as changes in income distribution and relative prices, demand for convenience food, health concerns, food safety, and generic advertising. According to Wohlgenant (1985), beef demand became more sensitive to poultry prices in the mid-1970s. His research suggested that changes in per capita beef consumption could be accounted for by changes in per capita real income and changes in relative prices of competing meats, especially poultry. Tests from Eales and Unnevehr (1988) for structural change in the demand for meat products showed an exogenous constant annual 6.4% growth in chicken demand from 1965 to 1985 and a 3.5% decline in beef table cut demand after 1974. Adhikari et al. (2006) found cholesterol information reduced U.S. demand for beef and pork and increased chicken demand. Rickertsen, Kristofersson, and Lothe (2003) concluded that chicken demand in Finland, Norway, and Sweden increased as information about cholesterol was more widely disseminated. They also found that chicken is a strong substitute for beef. Piggott et al. (2007) examined the impacts of generic pork and beef advertising and food safety information on the demand for beef, pork, and poultry. They found impacts of advertising and food safety effects to be economically small compared with price and expenditure effects. This research will study demand change for a broad category of protein sources including beans, dairy products, eggs, and different species of meat.

Theoretical Framework

Consumer purchasing behavior can be impacted by economic events, but change is not always immediate. Thus, the timing of behavioral change is a factor to be measured. For example, consumer expenditure patterns on protein sources may be affected by the Great Recession, but expenditure may not respond immediately because consumer eating habits change gradually and because recessions happen over time rather than at a point in time. State space models (SSM) (Harvey, 1989) are widely used in a variety of fields such as engineering, statistics, econometrics, and agriculture for analyzing time series data. The Kalman filter and smoother (KFS) algorithm is the main computational tool for using SSM for data analysis. The smoothing phase produces useful diagnostic measures that can indicate breaks in the state evolution process (De Jong and Penzer, 1998). In this article, the state space model test (SSMT) is used to find the break date for changes in expenditure patterns for protein sources.

The general form of the state space model is:

(1a) $\mathbf{Y}_t = \mathbf{Z}_t\boldsymbol{\alpha}_t + \mathbf{X}_t\boldsymbol{\beta} + \boldsymbol{\varepsilon}_t$ Observation equation

(1b) $\boldsymbol{\alpha}_{t+1} = \mathbf{T}_t\boldsymbol{\alpha}_t + \boldsymbol{W}_{t+1}\boldsymbol{\gamma} + \boldsymbol{c}_{t+1} + \boldsymbol{\eta}_{t+1}$ State transition equation

(1c) $\boldsymbol{\alpha}_1 = \boldsymbol{c}_1 + \mathbf{A}_1\boldsymbol{\delta} + \mathbf{W}_1\boldsymbol{\gamma} + \boldsymbol{\eta}_1$ Initial condition

where vectors and matrices are denoted by boldface letters; Greek letters (such as $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$) are unobserved or latent quantities estimated from the data and represent model parameters, latent states, and noise variables; and capital letters (such as X, Y) are observed data variables. Equation (1a) is the observation equation and describes the relationship of response vector $\mathbf{Y}_t$, the primary variable of interest, and unobserved vectors $\boldsymbol{\alpha}_t$, $\boldsymbol{\beta}$, $\boldsymbol{\varepsilon}_t$. Time-varying vector $\boldsymbol{\alpha}_t$ is the state and assumed to follow the state transition equation and the associated initial condition. The elements of $\boldsymbol{\alpha}_t$ often correspond to key features of the time series, such as time trend, seasonal factors, and other time-related factors. Vector $\boldsymbol{\alpha}_t$ evolves in time as a first-order vector autoregression. Time-invariant vector $\boldsymbol{\beta}$ is the regression coefficient vector associated with **X**, which contains variables not defined by time. Vector $\boldsymbol{\varepsilon}_t$ is the observation disturbances and assumed as a sequence of independent, zero-mean, normal random vectors with covariances σ_t^2 . The state transition equation is represented in Equation (1b) and measures changes in the time related coefficient vectors. Equation (1b) postulates that a new instance of the state $\boldsymbol{\alpha}_{t+1}$ is obtained by its previous instance $\boldsymbol{\alpha}_t$ and matrix $\mathbf{T}_t$, and by adding three more terms: a known nonrandom vector $\boldsymbol{c}_{t+1}$; a regression term $\boldsymbol{W}_{t+1}\boldsymbol{\gamma}$, where $\boldsymbol{W}_{t+1}$ is a design matrix with fully known elements and $\boldsymbol{\gamma}$ is the regression vector**;** and a random disturbance vector $\boldsymbol{\eta}_{t+1}$, assumed to be independent, zero-mean, and normal random vectors with covariances Q_t. Equation (1c) is initial condition which describes the starting condition of the state evolution equation. The starting state vector $\boldsymbol{\alpha}_1$ is the sum of a known nonrandom vector $\boldsymbol{c}_1$, a mean-zero Normal vector $\boldsymbol{\eta}_1$, and terms $\mathbf{A}_1\boldsymbol{\delta}$ and $\mathbf{W}_1\boldsymbol{\gamma}$**.** The term $\mathbf{A}_1\boldsymbol{\delta}$ represents the effect of vector $\boldsymbol{\delta}$ and matrix $\mathbf{A}_1$ is completely known. The state vector $\boldsymbol{\alpha}_t$ is often composed of independent subsections. For example, vector $\boldsymbol{\alpha}_t$ can be divided into two disjoint subsections, $\boldsymbol{\alpha}_t^a$ and $\boldsymbol{\alpha}_t^b$. Correspondently, the term $\mathbf{Z}_t\boldsymbol{\alpha}_t$ in the observation equation splits into the sum of $\mathbf{Z}_t^a\boldsymbol{\alpha}_t^a$ and $\mathbf{Z}_t^b\boldsymbol{\alpha}_t^b$.

If we focus on one time series of data and examine time trend and monthly effect, we can use the following model:

(2) $$y_t = \mu_t + \psi_t + \epsilon_t$$

where y_t denotes the time series data, μ_t denotes the time trend component, ψ_t denotes the monthly seasonal component, and $\epsilon_t \sim N(0, \sigma^2)$. Equation (2) analyzed by a state space model becomes:

(3a)	$y_t = \mathbf{Z}\boldsymbol{\alpha}_t + \epsilon_t$	$\epsilon_t \sim N(0, \sigma^2)$	Observation equation
(3b)	$\boldsymbol{\alpha}_t = \mathbf{T}\boldsymbol{\alpha}_{t-1} + \boldsymbol{\eta}_t$	$\boldsymbol{\eta}_t \sim \boldsymbol{N}(\mathbf{0}, \mathbf{Q})$	State transition equation
(3c)	$\boldsymbol{\alpha}_1 = \boldsymbol{\alpha}$		Initial condition

where $\boldsymbol{\alpha}_t$ is a 13-dimensional state vector formed by joining two vectors: $\boldsymbol{\alpha}_t^{\mu}$ and $\boldsymbol{\alpha}_t^{\psi}$. The vector $\boldsymbol{\alpha}_t^{\mu}$ is a 2-dimensional vector that corresponds to the trend component μ_t, while vector $\boldsymbol{\alpha}_t^{\psi}$ is an 11-dimensional vector that corresponds to the monthly seasonal component ψ_t. The vectors $\boldsymbol{\alpha}_t^{\mu}$ and $\boldsymbol{\alpha}_t^{\psi}$ follow separate state transition equations that depend on the transition matrices $\mathbf{T}^{\mu}$ and $\mathbf{T}^{\psi}$ and the covariances $\mathbf{Q}^{\mu}$ and $\mathbf{Q}^{\psi}$, respectively. So, $\mathbf{T}$ = Diag ($\mathbf{T}^{\mu}$, $\mathbf{T}^{\psi}$) and $\mathbf{Q}$ = Diag ($\mathbf{Q}^{\mu}$, $\mathbf{Q}^{\psi}$). Similarly, the 13-dimensional design vector $\mathbf{Z}$ splits into two blocks, $\mathbf{Z}^{\mu}$ and $\mathbf{Z}^{\psi}$. Thus, $\mu_t = \mathbf{Z}^{\mu}\, \boldsymbol{\alpha}_t^{\mu}$ and $\psi_t = \mathbf{Z}^{\psi}\, \boldsymbol{\alpha}_t^{\psi}$. Initial condition chooses the beginning of time.

Suppose that an unanticipated change of unknown size takes place in the i_0th element of the state at time $(t_0 + 1)$. Equation 1b then is adjusted to account for this change by including a dummy regressor in the state equation as follows:

(4) $$\boldsymbol{\alpha}_{t+1} = \mathbf{T}_t \boldsymbol{\alpha}_t + \boldsymbol{W}_{t+1}\boldsymbol{\gamma} + \boldsymbol{c}_{t+1} + \boldsymbol{D}_{t+1}\boldsymbol{\delta} + \boldsymbol{\eta}_{t+1}$$

where $\mathbf{D}_{t_0+1}[i_0] = 1$and $\mathbf{D}_t[i] = 0$ for all other t and i. De Jong and Penzer (1998) efficiently generated estimates of such one-time changes in the state at all distinct time points in the sample in one smoothing pass. A statistically significant value of $\boldsymbol{\delta}$ at a time point t_0 indicates an unanticipated change in $\boldsymbol{\alpha}_0$. Because of the evolutionary nature of the state equation, a one-time change in the state affects all the subsequent states, which in turn affect the subsequent observations. Thus, a significant unanticipated change in the state is a structural break.

To find a structural break in Equation 2, SSMT can be implemented to test whether $\boldsymbol{\alpha}_t$ in Equation 3b experienced an unexpected change at some time point $t = t_0$.

The null hypothesis is H_0: $\boldsymbol{\gamma} = \mathbf{0}$, which indicates no change, and H_a: $\boldsymbol{\gamma} \neq \mathbf{0}$, which indicates a structural break occurs at t_0. The transition equation (Equation 3b) becomes

(5) $$\boldsymbol{\alpha}_t = \mathbf{T}\boldsymbol{\alpha}_{t-1} + \mathbf{I}_{t=t_0}\boldsymbol{\gamma} + \boldsymbol{\eta}_t$$

where $\boldsymbol{\gamma}$ is the change vector at t_0, $\mathbf{I}_{t=t_0}$ is a 13-dimensional identity matrix when $t = t_0$, and a zero matrix otherwise. After testing H_0: $\boldsymbol{\gamma} = \mathbf{0}$ at each time t_0 in the sample, a plots graph of all the test statistics at each time is formed. The test statistic follows a chi-square distribution with 13 degrees of freedom. The significant peak in the plot indicates the break point location.

With the same logic, SSMT can be used to test for breaks in specific sections of the state. To test for monthly seasonal effect changes, we test H_0: $\boldsymbol{\gamma}^{\psi} = \mathbf{0}$ in the perturbed transition equation for the 11-dimesional state subsection $\boldsymbol{\alpha}_t^{\psi}$. We test H_0: $\boldsymbol{\gamma}^{\mu} = \mathbf{0}$ in the transition equation for the 2-dimesional state $\boldsymbol{\alpha}_t^{\mu}$ to examine whether time trend changes.

Structural break analysis is important, especially in obtaining accurate forecasts. Sometimes, a break point is unknown or there are multiple unknown structural changes in time series data. Bai and Perron (1998) propose several kinds of multiple structural change tests: (1) the test of no breaks versus a fixed number of breaks (*supF* test); (2) the equal and unequal weighted versions of double maximum tests of no break versus an unknown number of breaks given some upper bound (*UDmaxF* test and *WDmaxF* test); and (3) the test of l versus $l + 1$ breaks (supF $_{l+1|l}$ test). Bai and Perron (2003a, b, 2006) also discuss test implementation, commonly used critical values, and simulation analysis on these tests. Often, it is hard to define exact break points, but Bai and Perron tests offer break point estimates with confidence intervals. While inclusion of a time trend can measure whether gradual change in consumer expenditure patterns on protein sources has occurred, Bai and Perron tests can be used to detect whether structural change has also occurred in other forms. Such changes may be incorporated into modeling efforts.

One popular demand system is the almost ideal demand system (AIDS). Deaton and Muellbauer (1980) suggested a cost function consistent with the price-independent generalized logarithmic (PIGLOG) cost function:

(6) $$\ln c(P,u) = a(P) + ub(P),$$

with $a(P)$ and $b(P)$ as

(7) $$a(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + 0.5 \sum_{i=1}^{n} \sum_{l=1}^{n} \gamma_{il} \ln p_i \ln p_l,$$

(8) $$b(P) = \beta_0 \prod_{i=1}^{n} p_i^{\beta_i},$$

where $c(P,u)$ denotes cost function consisted of utility (u) and prices (P), terms $a(P)$ and $b(P)$ are functions of prices. The expenditure share for good n is

(9) $$w_i = \frac{\partial \ln c(P,u)}{\partial \ln p_i} = u\beta_i\beta_0 \prod_{k=1}^{n} p_k^{\beta_k} + \alpha_i + \sum_{k=1}^{n} \gamma_{ik} \ln p_k$$

Inverting the cost function yields

(10) $$u = \frac{\ln X - a(P)}{b(P)}$$

where X is total expenditure on goods. By substituting u back into (9), the expenditure share become equations as functions of only prices and expenditure:

(11) $$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right) + \varepsilon_i$$

where w_i is the share associated with the ith good, α_i is the constant coefficient in the ith share equation, γ_{ij} is the slope coefficient associated with the jth good in the ith share equation, p_j is the price on the jth good, X is the total expenditure on the system of goods, $\varepsilon_i \sim N(0, \sigma_i^2)$, P is the price index defined by

(12) $$\ln p = \alpha_0 + \sum_{i=1}^{n} \ln p_i + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j.$$

Homogeneity, adding-up, and symmetry restrictions are imposed by restricting $\sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} \alpha_i = 1$, and $\gamma_{ij} = \gamma_{ji}$.

The real world economic system is constantly subject to shocks, such as recession, which may impact consumer choice. But the standard AIDS model (Equation 11) does not allow its parameters to change, assuming implicitly consumer preferences do not change. Thus, the standard AIDS model is inadequate to present changes in consumer behavior over a long period. Assuming time-varying parameters helps to capture the dynamics in economic behavior. Time series of expenditure data may exhibit both time trend and seasonal effects. Therefore, we integrate time trend and monthly effects into AIDS to construct the Time-Varying AIDS (TV-AIDS) model as:

(13) $$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right) + a_i^c \cos\frac{2\pi t}{12} + a_i^s \sin\frac{2\pi t}{12} + a_i^t t + \varepsilon_i$$

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \ln p_i + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j$$

where *t* is time variable, a_i^c and a_i^s represent parameters on the trigonometric variables, and a_i^t is the parameter on the time variable. Classical demand restrictions are again imposed by

$\sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} \alpha_i = 1, \gamma_{ij} = \gamma_{ji}$

The parameters reflecting time trend, a_i^t, and monthly effects, a_i^c and a_i^s, go to intercept with α_i. Since the budget shares sum up to 1 (or because of adding-up restriction: $\sum_{i=1}^{n} \alpha_i = 1$), additional restrictions are imposed by

$\sum_{i=1}^{n} a_i^c = 0, \sum_{i=1}^{n} a_i^s = 0, \sum_{i=1}^{n} a_i^t = 0$

The price elasticity derived from the TV-AIDS model is:

(14) $$\eta_{ij} = \frac{\gamma_{ij} - \beta_i(\alpha_{j+} a_j^c \cos\frac{2\pi t}{12} + a_j^s \sin\frac{2\pi t}{12} + a_j^t t - \sum_{k=1}^{n} \gamma_{ij} \log p_k)}{w_i} - \delta_{ij}.$$

If i=j, δ_{ij}=1; and otherwise δ_{ij}=0. Expenditure elasticities are calculated as

(15) $$\eta_{iM} = 1 + \frac{\beta_i}{w_i}$$

Data

Data is taken from the Consumer Expenditure Survey (CES) conducted by the Bureau of Labor Statistics (BLS). The CES is a nationwide household survey administered every year since 1984 and designed to represent the total U.S. civilian noninstitutionalized population. Detailed data on food expenditures is collected for a two-week period from cross-sections of households. Data categories used in this study include protein sources represented by beef, pork, poultry, other meat, fish and sea food, eggs, dairy products, and dried beans, peas, and lentils from January 1998— December 2016. The CES data for these categories from January 1998— December 2016 is aggregated to construct monthly expenditure data of average expenditures per consuming unit. Expenditure data is matched with Consumer Price Indices (CPI) from BLS.

Monthly expenditure for each food product was calculated in two steps. First, we estimated average weekly expenditure for each household by protein source category and multiplied these expenditures by the number of weeks in each month to obtain average monthly household expenditure. Households that reported expenditures for a week that straddled two months were assigned to the month that contributed four or more days to the household's week. Then, we estimated the sample average for each year using sample weights to obtain the average monthly expenditure for the U.S. noninstitutionalized population. We also sorted CES data into different quintile income levels. Using the same method, we also obtained monthly expenditure data for the five quintile income levels.

Method

In this article, according to Equation (2), the expenditure pattern on protein sources is modeled as

(16) $$y_t = \mu_t + \psi_t + \epsilon_t$$

where y_t denotes the monthly expenditure on protein sources, μ_t denotes the trend component, ψ_t denotes the monthly seasonal component, and $\epsilon_t \sim N(0, \sigma^2)$. The expenditure pattern model is analyzed by a state space model as Equation (3). Then we use SSMT to find the break in the expenditure pattern for protein sources.

Bai and Perron test (supF $_{l+1|l}$ test) is also applied to examine whether the time trend of consumer expenditure patterns on protein sources changes. An expenditure-time regression is performed as

(17) $$y_i = t + \varepsilon_i$$

where y_i is the expenditure on protein sources in i^{th} month, t is time variable, and $\varepsilon_i \sim N(0, \sigma_i^2)$. Bai and Perron test is conducted to find structural change in time trend for this expenditure-time regression.

The Time-Varying AIDS is implemented to estimate the demand system for protein sources:

(18) $$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right) + a_i^c \cos\frac{2\pi t}{12} + a_i^s \sin\frac{2\pi t}{12} + a_i^t t + \varepsilon_i$$

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \ln p_i + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j$$

where w_i is the expenditure share associated with the i^{th} protein source, p_j is the price on the j^{th} protein source, X is the total expenditure on the system, P is price index, t is time variable, a_i^c and a_i^s represent parameters on the trigonometric variables, and a_i^t is the parameter on the time variable, and $\varepsilon_i \sim N(0, \sigma_i^2)$. Restrictions are imposed by

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \alpha_i = 1, \gamma_{ij} = \gamma_{ji}, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} a_i^c = 0, \sum_{i=1}^{n} a_i^s = 0, \sum_{i=1}^{n} a_i^t = 0$$

Data for the average consumer and for the five quintile income levels are analyzed, respectively. We use iterated seemingly unrelated regression (ITSUR) method to estimate the time-varying demand systems with centered prices. We then calculate expenditure and price elasticities for protein sources before and after the break date using the estimates from the TV-AIDS.

Results

Figure 4.1 shows monthly average household nominal and real expenditure on total protein sources from January 1998 to December 2016. Total protein source real expenditure seems flatted with a little decrease trend. Total protein source nominal expenditure increases across time; however, slope of the trend becomes steeper in later periods. That is total protein source expenditure increases faster in the later period than in the early period.

Table 4.1 reports mean monthly household protein source expenditures across different income strata as well as average household income by quintile income level for 2016. Consumers spend the most on beef among meat products, including beef, pork, poultry, fish and seafood. The highest expenditure overall is on dairy products and the lowest expenditure is on dried beans. Dairy products include a wide variety of products, such as milk, cheese, ice cream, and yogurt, so this result is not unexpected. Generally, expenditures on protein sources increase with income when comparing across the five income quintiles, but expenditure on dried beans is similar across income strata. This may because dried beans are relatively inexpensive and because dried beans are relatively small part of a traditional American diet. Total protein source expenditure in lower income strata, Income Quintile 1 to 3, is lower than the average household. Income Quintile 1 has the lowest total protein source expenditure, which is 36% lower than the average household. Higher income groups, including Income Quintile 4 and 5, have higher total protein source expenditure than the average household. Total protein source expenditure in Income Quintile 5 is the highest with 45% higher expenditure than the average household.

Figure 4.2 illustrates SSMT statistics for structural breaks in protein source expenditure patterns during the data period. Three peak clusters are centered around December 2004, April 2011, and August 2014. Time trend is the source of change for December 2001 and April 2011, while the seasonal expenditure pattern is the source of change for August 2014. The break date is highly probably in the period from October 2009 to January 2012 suggested by the peak cluster around April 2011. Table 4.2 report results from Bai and Perron’s structural change test (supF $_{l+1|l}$ test) for total expenditure on protein sources. Three break dates near December 2001, December 2004, and September 2009 are detected. A timeline of structural break indications by test and type are illustrated in Figure 4.3. Taken together, results suggest a break date of protein source expenditure pattern near October 2009. This is consistent with potential influence from the Great Recession period. These results are incorporated into the TV-AIDS model in

Equation 18 by allowing model parameters to change due to time trend and seasonal factor changes. The break date, October 2009, is also incorporated into elasticity analysis.

Table 4.3 presents coefficient estimates of the TV-AIDS model for protein sources for the average household. For beef expenditure share, time trend is negative, indicating that predicted beef expenditure share for the average household among protein sources has trended down over time. Fish and seafood expenditure share for the average household exhibits the opposite pattern with a positive time trend. Predicted household expenditure share of fish and seafood among protein sources has increased across the time period. The same is true for eggs and dairy product expenditure shares. Time trends for both are positive, indicating that the predicted expenditure shares of eggs and dairy products increase across time. These results suggest that households have diversified their protein intake over time.

Tables 4.4 through 4.8 report coefficient estimates of the TV-AIDS model for protein sources for different income quintile groups. For Income Quintile 1 households (Table 4.4), significance of the time trend coefficient indicates that predicted pork expenditure share decreased over time, while predicted expenditure shares of fish and seafood and dairy products increased over time. With no changes in protein source budget over time, households in Income Quintile 1 would buy less pork and more fish and seafood, and dairy products across time. Time trend is positive for Income Quintile 2 households (Table 4.5) for fish and seafood expenditure share, indicating that predicted share among protein sources increased across the time period. For Income Quintile 3 households (Table 4.6), time trend for bean expenditure share is positive, indicating that predicted household bean expenditure share among protein sources trended up over time.

Time trend has no effect on predicted expenditure shares of protein sources for Income Quintile 4 households (table 4.7), indicating that eating habits regarding protein sources for these households may not change. Time trend is negative for Income Quintile 5 households (table 4.8) for beef expenditure share, time trend is negative, indicating that predicted beef expenditure share among protein sources trended down over time. Eggs and dairy products expenditure shares for households in Income Quintile 5 exhibit opposite patterns with positive time trends. Predicted household expenditure shares of eggs and dairy products among protein sources increased across time. Generally, households in different income quintile groups have different trends in expenditure shares among protein sources. However, households across different income quintile groups are likely to spend less on red meat, such as beef and pork across time, and to buy more diversified protein sources, for example, they would like to spend more on fish and seafood, beans, eggs and dairy products over time.

Table 4.9 reports own-price elasticities of demand for protein sources across different income strata pre- and post-October 2009. For average households, the own-price elasticity for beef becomes more inelastic post-October 2009. For example, a 1% increase in beef price resulted in a 6% decreased in beef quantity demanded pre-October 2009, but a decrease of 0.54% post-October 2009. Similarly, own-price elasticity for pork for average households becomes more inelastic post-October 2009. Average households have less response to the increase of prices in beef and pork post-October 2009. For average households, the own-price elasticity for egg exhibits the opposite pattern, becoming less inelastic post-October 2009, at -0.17% pre-October 2009, but -0.37% post-October 2009. The same is true for beans. The-own price elasticity for beans for average households becomes less inelastic post-October 2009. The own- price elasticity for fish and seafood for average households becomes more elastic post-October 2009. Average households have a stronger response to the increase of prices of eggs, beans, and fish and seafood post-October 2009.

For lower income households in Income Quintiles 1-3, own-price elasticities for traditional protein sources, including beef, pork and poultry, did not change post-October 2009, as compared to pre-October 2009. For households in both Income Quintile 1 and 2, own-price elasticity for eggs became less inelastic post-October 2009. Similarly, own-price elasticity for dairy products for Income Quintile 2 households became less inelastic post-October 2009. For households in Income Quintile 3, own price-elasticities for eggs and dairy products became less inelastic post-October 2009, while own-price elasticity for fish and seafood became more elastic.

Own-price elasticity for eggs is less inelastic for Income Quintile 4 and 5 households post-October 2009. However, for households in Income Quintile 4, the own-price elasticity for fish and seafood is more elastic post-October 2009, while Income Quintile 5 exhibits more inelastic own-price elasticity for beef post-October 2009.

Results suggest that the change in beef's own-price elasticity measure for average households may be primarily driven by the households in Income Quintile 5. Own-price elasticity measure for fish and seafood for average households appears to be more influenced by middle income households, as own-price elasticity for fish and seafood is more elastic for households in Income Quintile 3 and 4 after October 2009. Eggs became less own-price inelastic across income strata. In general, higher income households became less sensitive to beef price increases. However, middle income households became more sensitive to price increases for fish and seafood. Consumers became less sensitive to price increases for eggs across all income strata.

Table 4.10 presents expenditure elasticities of demand for protein sources across different income strata pre- and post-October 2009. For the average household, expenditure elasticities for beef, pork, and fish and seafood are elastic, while they are inelastic for beans, poultry, eggs, and dairy products. The expenditure elasticity for beef is larger post-October 2009 for the average household and is expenditure elastic at 1.41 pre-October 2009 and 1.46 after October 2009. Similarly, expenditure elasticities for pork and dairy products for the average households are larger post-October 2009 than pre-October 2009.

Expenditure elasticities for beef, pork, beans, and fish and seafood are elastic for households in Income Quintile 1, but inelastic for poultry, eggs, and dairy products. Expenditure elasticities for beef, pork, fish and seafood, eggs, and dairy products are all larger post-October 2009. For households in Income Quintile 2, expenditure elasticities for beef, pork, and poultry are elastic, but inelastic for beans, fish and seafood, eggs, and dairy products. As with Quintile 1, Quintile 2 expenditure elasticities for beef, pork, beans, eggs, and dairy products are larger post-October 2009. Interestingly, the expenditure elasticity for beans is negative pre-October 2009 (-0.13), but became positive post-October 2009 (0.27) for households in Income Quintile 2. This indicates Quintile 2 consumers would allocate additional expenditure away from beans before October 2009, but it is partially allocated to more beans after October 2009. For households in Income Quintile 3, expenditure elasticities are elastic for beef, pork, poultry and fish and seafood, but inelastic for beans, eggs, and dairy products. Expenditure elasticities for beef, pork, fish and seafood, and dairy products are larger post-October 2009. However, expenditure elasticity for poultry for households in Income Quintile 3 is smaller post-October 2009, at 1.25% pre-October 2009, but 1.24% post-October 2009. Expenditure elasticities for beef, pork, and fish and seafood are elastic for households in Income Quintile 4, but inelastic for beans, poultry, eggs, and dairy products are inelastic. Expenditure elasticities for beef, pork, and dairy products are larger post-October 2009. For households in Income Quintile 5, expenditure elasticities for beef, pork, beans, and fish and seafood are elastic, but inelastic for poultry, eggs, and dairy products are inelastic. Expenditure elasticities for beef, eggs, and dairy products are larger post-October 2009. In general, expenditure elasticities for beef and dairy products increase across all income strata post-October 2009.

Expenditure elasticity for beans is inelastic for middle income households (Income Quintile 2-4), while elastic for households in the lowest and highest income quintiles (Income Quintile 1 and 5). If protein source expenditure increases, bean quantity demanded for households in the lowest and highest income quintiles will increase more than middle income households. Expenditure elasticity for poultry is elastic for middle income households (Income Quintile 2 and 3), while inelastic for households in lower and higher income quintiles (Income Quintile 1, 4 and 5). If protein source expenditure increases, poultry quantity demanded for middle income households will increase more than households in lower and higher income quintiles. The expenditure elasticity for fish and seafood is inelastic for Income Quintile 2, while elastic for households in other income quintiles. Therefore, purchasing behavior for households in Income Quintile 2 is different from other income quintiles due to expenditure elasticities for beans and fish and seafood.

Conclusion

Results suggest that household expenditure patterns on protein sources may have been affected by the Great Recession, though expenditure response to the recession may not have been immediate because household eating habits change gradually and because the recession happened over time rather than at a point in time. Our finding suggests the break date of expenditure patterns for protein sources near October 2009.

By considering time trends in protein source expenditure shares, this article indicates that the average household will purchase less beef and more fish and seafood, eggs and dairy products in future. Although they exhibit different trends in protein source expenditures, households in different income quintiles are likely to purchase less red meat, such as beef and pork, and to buy more diversified protein sources in the future. Similar to the average household result, they likely purchase more fish and seafood, beans, eggs and dairy products. Gabbett (2017) reports similar results from a recent Nielsen survey which found that households in Canada and the United States intend to eat more fish, seafood and legumes, and that 22% of Americans plan to eat less meat. This suggests that, combined with our results, households will expend more on non-red meat protein sources, and protein intake will be from a more diversified set of protein sources, eggs and dairy products.

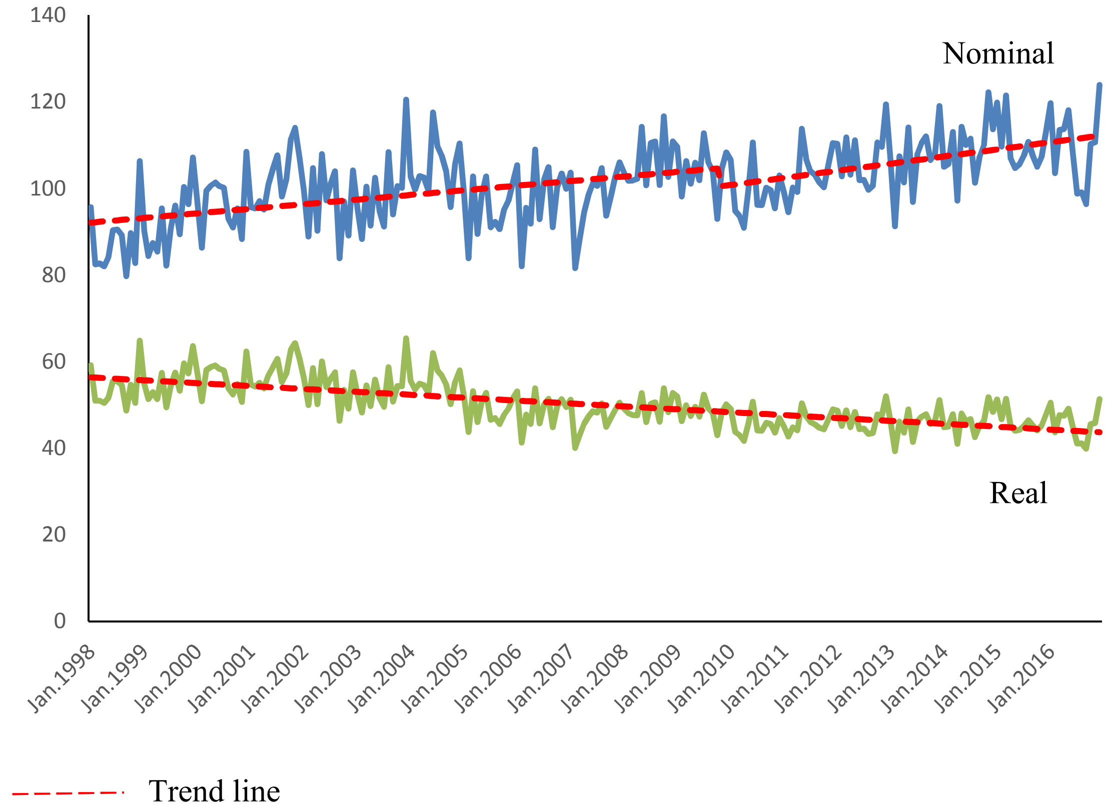
Our results indicate that own-price elasticity for beef became more inelastic for the average household post-October 2009, which appears to be driven by changes in beef's own-price elasticity for households in the highest income quintile (Income

Quintile 5). Own-price elasticity for fish and seafood became more elastic for average households post-October 2009. This change stems mainly from middle income households. Own-price elasticity for eggs became less inelastic across all income strata post-October 2009. In general, households in higher income quintiles became less sensitive to price increase for beef. Middle income households became more sensitive to price increases for fish and seafood. Households became less sensitive to price increases for eggs across all income strata.

Expenditure effect on demand for protein sources suggests that if protein source expenditure increases, quantities demanded of beef and dairy products will increase relatively more across income strata post-October 2009, as compared to the quantities increase pre-October 2009. Interestingly, for households in Income Quintile 2, an increase in protein source expenditure decreases quantity demanded for beans pre-October 2009 but has the opposite effect post-October 2009. Expenditure elasticity for fish and seafood is inelastic for Income Quintile 2, while it is elastic for households in other income quintiles.

As households focus on overall health and wellness, the demand for food and beverage products that are rich in protein may have a unique opportunity to increase. Half of North Americans eat a form of protein with every meal and around one-third agree that the source of protein matters (Gabbett, 2017). There are clear growth opportunities to satisfy consumers' protein preferences.

Eales and Unnevehr (1988) attempted to address two questions: (1) do consumers allocate expenditures among meats by animal origin or by product type? and (2) does disaggregation of meat into products in a meat demand model give insight into the causes of structural change? They estimated two meat demand systems with the almost ideal demand system (AIDS). The first system includes aggregate chicken, beef, and pork demand, while the second system disaggregates chicken demand into whole birds and parts/processed products and disaggregates beef into hamburger and table cuts. The result showed that consumers choose among meat products rather than meat aggregates such as "beef" or "chicken". Menkhaus et al. (1990) focused on factors influencing different purchasing patterns for beef. Specifically, purchasing patterns for beef, including roasts, steaks and ground beef, are related to consumer health-related concerns and to selected demographic characteristics. Their research suggested identifying factors responsible for changing consumption patterns of different products, rather than aggregate consumption. However, few studies have followed to examine consumption patterns for specific products, such as cuts of meat, as opposed to species. Future research may be conducted to determine whether there is structural change in purchasing patterns for disaggregated food products. For example, trading down within beef may occur in recent recessionary periods.



Source: Consumer Expenditure Survey (CES) conducted by the Bureau of Labor Statistics (BLS).
Note: Protein sources: beef, pork, poultry, fish and seafood, eggs, dairy products, dried beans, and other meat. Real expenditure is deflected by all item CPI from BLS.

Figure 4.1. Monthly average household nominal expenditure on protein sources, January 1998 – December 2016.

Table 4.1. Average Monthly Household Nominal Expenditures on Protein Sources across Different Income Strata, 1998-2016

	Beef ($)	Pork ($)	Poultry ($)	Fish and Seafood ($)	Eggs ($)	Dairy Products ($)
Average household	19.60	13.82	12.77	10.12	3.71	31.84
	(2.63)	(1.73)	(1.69)	(1.34)	(0.90)	(3.42)
Income Quintile 1	12.02	9.70	8.65	6.19	2.82	19.69
	(3.04)	(2.27)	(1.90)	(2.12)	(0.77)	(3.19)
Income Quintile 2	16.41	12.52	10.49	7.79	3.41	25.28
	(4.79)	(2.79)	(2.27)	(2.01)	(0.86)	(3.38)
Income Quintile 3	18.83	13.37	11.94	9.10	3.65	29.80
	(3.59)	(2.61)	(2.55)	(2.16)	(1.03)	(3.85)
Income Quintile 4	22.67	15.62	14.40	11.06	3.98	36.64
	(6.12)	(3.10)	(2.78)	(2.66)	(1.16)	(4.60)
Income Quintile 5	28.01	17.91	18.40	16.43	4.71	47.81
	(6.21)	(3.29)	(3.39)	(3.58)	(1.48)	(7.24)

Note: Standard deviations are in parentheses.
Source: Consumer Expenditure Survey (CES) conducted by the Bureau of Labor Statistics (BLS).

Table 4.1. Average Monthly Household Nominal Expenditures on Protein Sources across Different Income Strata, 1998-2016 (Continued)

	Dried Beans ($)	Other Meat ($)	Total Expenditure ($)	Relative Total Expenditure to Average Household (%)	Income in 2016 ($)
Average household	0.34	9.24	101.44	100	
	(0.14)	(1.14)	(8.89)		
Income Quintile 1	0.28	5.87	65.22	64	<21282
	(0.20)	(1.30)	(10.23)		
Income Quintile 2	0.35	7.48	83.73	83	21282<38514
	(0.21)	(1.57)	(11.09)		
Income Quintile 3	0.35	8.77	95.81	94	38514<65000
	(0.22)	(1.59)	(11.05)		
Income Quintile 4	0.34	10.78	115.49	114	65000<10506
	(0.24)	(2.09)	(13.23)		
Income Quintile 5	0.40	13.35	147.02	145	>10506
	(0.28)	(2.86)	(19.01)		

Note: Standard deviations are in parentheses.
Source: Consumer Expenditure Survey (CES) conducted by the Bureau of Labor Statistics (BLS).

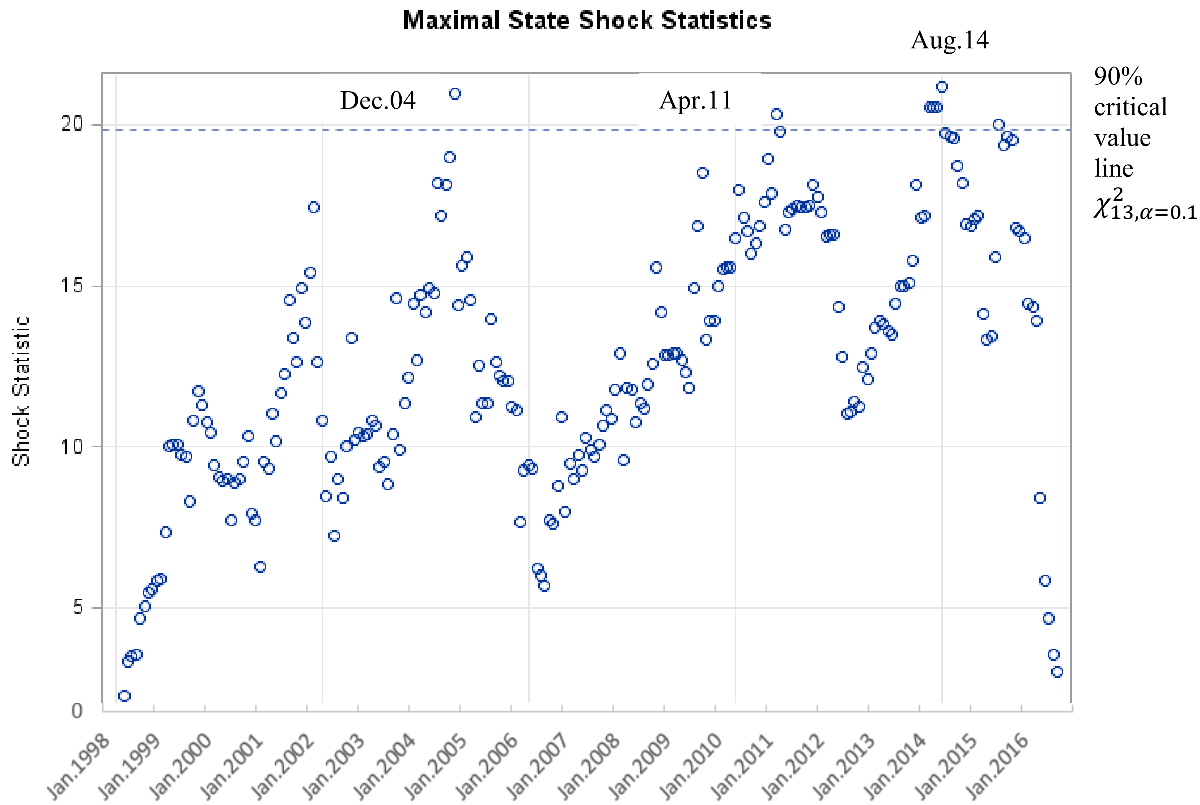
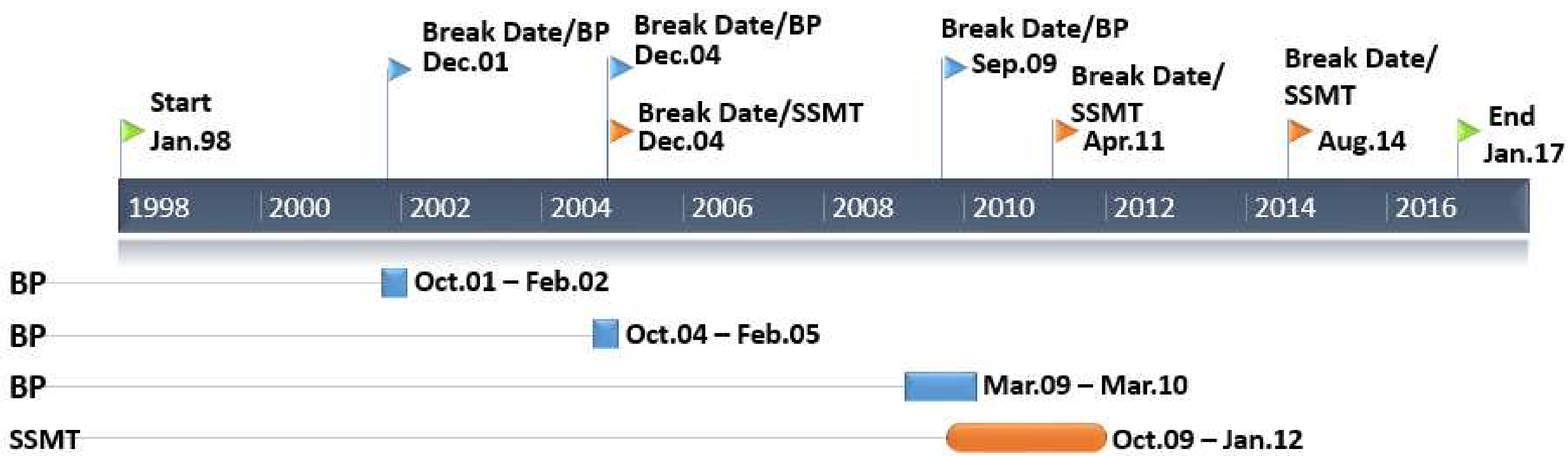


Figure 4.2. State Space Model Test for protein source expenditure by month, 1998-2016.

Table 4.2. Bai and Perron's Structural Change Test for Expenditure on Protein Sources

Break Dates	95% Confidence Interval around Break Date	
	Upper Bound	Lower Bound
Dec.2001	October 2001	February 2002
Dec.2004	October 2004	February 2005
Sep.2009	March 2009	March 2010

Note: Bai and Perron test is specified as sup$F_{l+1|l}$ test.



Note: BP denotes Bai and Perron's supF $_{l+1|l}$ test, SSMT denotes space state model test

Figure 4.3. Timeline of structural break indications by test and type.

Table 4.3. Parameter Estimates from Time-Varying AIDS Model for Average Household

Price of	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0658*	-0.0101	-0.0036	0.0204	-0.0400*	-0.0093*	-0.0094	-0.0139
	(0.0328)	(0.0225)	(0.0029)	(0.0232)	(0.0184)	(0.0054)	(0.0237)	(0.0160)
Pork	-0.0101	0.0351	0.0058*	0.0067	0.0025	0.0010	-0.0656*	0.0245
	(0.0225)	(0.0289)	(0.0029)	(0.0235)	(0.0171)	(0.0055)	(0.0203)	(0.0165)
Beans	-0.0036	0.0058*	0.0029*	-0.0043	0.0030	0.0002	-0.0027	-0.0014
	(0.0029)	(0.0029)	(0.0015)	(0.0037)	(0.0007)	(0.0007)	(0.0024)	(0.0030)
Poultry	0.0204	0.0067	-0.0043	0.0290	0.0754*	0.0044	-0.0763*	-0.0554*
	(0.0232)	(0.0235)	(0.0037)	(0.0384)	(0.0203)	(0.0061)	(0.0228)	0.0199
Fish and Seafood	-0.0400*	0.0025	0.0030	0.0754*	-0.0700*	0.0103*	-0.0296*	0.0484*
	(0.0184)	(0.0171)	(0.0007)	(0.0203)	(0.0190)	(0.0043)	(0.0170)	(0.0133)
Eggs	-0.0093*	0.0010	0.0002	0.0044	0.0103*	0.0270*	-0.0235*	-0.0101*
	(0.0054)	(0.0055)	(0.0007)	(0.0061)	(0.0043)	(0.0020)	(0.0052)	(0.0043)
Dairy	-0.0094	-0.0656*	-0.0027	-0.0763*	-0.0296*	-0.0235*	0.2222*	-0.0152
	(0.0237)	(0.0203)	(0.0024)	(0.0228)	(0.0170)	(0.0052)	(0.0289)	(0.0149)
Other Meats	-0.0139	0.0245	-0.0014	-0.0554*	0.0484*	-0.0101*	-0.0152	0.0230
	(0.0160)	(0.0165)	(0.0030)	0.0199	(0.0133)	(0.0043)	(0.0149)	(0.0205)
Intercept	-0.1620*	-0.0940*	0.0070	0.1478*	0.0484	0.0398*	0.8642*	0.1488*
	(0.0714)	(0.0464)	(0.0045)	(0.0476)	(0.0461)	(0.0120)	(0.0556)	(0.0305)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.3. Parameter Estimates from Time-Varying AIDS Model for Average Household (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.0819*	0.0511*	-0.0011	-0.0028	0.0091	-0.0019	-0.1227*	-0.0136*
	(0.0147)	(0.0095)	(0.0009)	(0.0098)	(0.0095)	(0.0025)	(0.0115)	(0.0062)
Cos	-0.0072*	0.0046*	0.0002*	0.0069*	-0.0009	0.0015*	-0.0006	-0.0044*
	(0.0015)	(0.0010)	(0.0001)	(0.0010)	(0.0010)	(0.0003)	(0.0012)	(0.0007)
Sin	-0.0020	0.0012	0.0003*	-0.0021*	0.0046*	0.0012*	-0.0034*	0.0001
	(0.0015)	(0.0010)	(0.0001)	(0.0010)	(0.0010)	(0.0003)	(0.0012)	(0.0007)
t	-0.0002*	-0.0001	0.0000	-0.0001	0.0001*	0.0001*	0.0001*	0.0000
	(0.0000)	(0.0000)	0.0000	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
R-squared	0.4955	0.4008	0.4753	0.2624	0.1153	0.8576	0.6197	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.4. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 1

Price of	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0425	0.0417	0.0009	0.0485	-0.0830*	0.0096	-0.0571	-0.0030
	(0.0589)	(0.0462)	(0.0079)	(0.0445)	(0.0392)	(0.0122)	(0.0462)	(0.0362)
Pork	0.0417	0.0505	0.0078	-0.0075	0.0011	-0.0051	-0.0899**	0.0014
	(0.0462)	(0.0616)	(0.0078)	(0.0468)	(0.0381)	(0.0127)	(0.0436)	(0.0378)
Beans	0.0009	0.0078	0.0099*	-0.0205*	-0.0037	-0.0013	0.0047	0.0022
	(0.0079)	(0.0078)	(0.0041)	(0.0099)	(0.0067)	(0.0021)	(0.0067)	(0.0081)
Poultry	0.0485	-0.0075	-0.0205*	0.1107	0.0830*	-0.0127	-0.0857**	-0.1158*
	(0.0445)	(0.0468)	(0.0099)	(0.0735)	(0.0412)	(0.0129)	(0.0458)	(0.0431)
Fish and Seafood	-0.0830*	0.0011	-0.0037	0.0830*	-0.0518	0.0161	-0.0560	0.0942*
	(0.0392)	(0.0381)	(0.0067)	(0.0412)	(0.0462)	(0.0107)	(0.0407)	(0.0310)
Eggs	0.0096	-0.0051	-0.0013	-0.0127	0.0161	0.0359*	-0.0062	-0.0364*
	(0.0122)	(0.0127)	(0.0021)	(0.0129)	(0.0107)	(0.0050)	(0.0126)	(0.0104)
Dairy	-0.0571	-0.0899*	0.0047	-0.0857*	-0.0560	-0.0062	0.2603*	0.0300
	(0.0462)	(0.0436)	(0.0067)	(0.0458)	(0.0407)	(0.0126)	(0.0652)	(0.0353)
Other Meats	-0.0030	0.0014	0.0022	-0.1158*	0.0942*	-0.0364*	0.0300	0.0272
	(0.0362)	(0.0378)	(0.0081)	(0.0431)	(0.0310)	(0.0104)	(0.0353)	(0.0489)
Intercept	-0.0466	0.0292	-0.0001	0.1659*	-0.0545	0.0868*	0.6854*	0.1339*
	(0.0587)	(0.0434)	(0.0057)	(0.0399)	(0.0498)	(0.0132)	(0.0573)	(0.0312)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.4. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 1 (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.0592*	0.0337*	0.0012	-0.0068	0.0297*	-0.0101*	-0.0966*	-0.0102
	(0.0130)	(0.0095)	(0.0012)	(0.0088)	(0.0112)	(0.0030)	(0.0128)	(0.0069)
Cos	-0.0038	0.0051*	0.0003	0.0071*	-0.0014	0.0021*	-0.0060*	-0.0034*
	(0.0028)	(0.0021)	(0.0003)	(0.0020)	(0.0024)	(0.0007)	(0.0028)	(0.0016)
Sin	-0.0017	-0.0001	0.0006*	0.0005	0.0048*	0.0008	-0.0051*	0.0001
	(0.0028)	(0.0022)	(0.0003)	(0.0020)	(0.0024)	(0.0006)	(0.0028)	(0.0016)
t	-0.0001	-0.0002*	0.0000	0.0000	0.0002*	0.0000	0.0002*	-0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0000)
R-squared	0.1888	0.2112	0.1358	0.1263	0.0713	0.5485	0.3177	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.5. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 2

	Demand for							
Price of	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0929	0.0299	-0.0079	-0.0405	-0.1010*	0.0010	0.0407	-0.0150
	(0.0672	(0.0498)	(0.0069)	(0.0441)	(0.0387)	(0.0118)	(0.0465)	(0.0373)
Pork	0.0299	-0.0308	-0.0042	0.0398	0.0524	-0.0019	-0.0728*	-0.0124
	(0.0498)	(0.0652)	(0.0067)	(0.0460)	(0.0377)	(0.0122)	(0.0424)	(0.0382)
Beans	-0.0079	-0.0042	-0.0014	0.0102	0.0058	0.0005	-0.0096*	0.0066
	(0.0069)	(0.0067)	(0.0035)	(0.0084)	(0.0057)	(0.0017)	(0.0056)	(0.0069)
Poultry	-0.0405	0.0398	0.0102	-0.0581	0.0571	0.0004	-0.0023	-0.0067
	(0.0441)	(0.0460)	(0.0084)	(0.0677)	(0.0386)	(0.0116)	(0.0414)	(0.0409)
Fish and Seafood	-0.1010*	0.0524	0.0058	0.0571	-0.0703*	0.0172*	0.0115	0.0274
	(0.0387)	(0.0377)	(0.0057)	(0.0386)	(0.0404)	(0.0094)	(0.0350)	(0.0300)
Eggs	0.0010	-0.0019	0.0005	0.0004	0.0172*	0.0217*	-0.0427*	0.0038
	(0.0118)	(0.0122)	(0.0017)	(0.0116)	(0.0094)	(0.0043)	(0.0109)	(0.0097)
Dairy	0.0407	-0.0728*	-0.0096*	-0.0023	0.0115	-0.0427*	0.0948*	-0.0195
	(0.0465)	(0.0424)	(0.0056)	(0.0414)	(0.0350)	(0.0109)	(0.0561)	(0.0334)
Other Meats	-0.0150	-0.0124	0.0066	-0.0067	0.0274	0.0038	-0.0195	0.0158
	(0.0373)	(0.0382)	(0.0069)	(0.0409)	(0.0300)	(0.0097)	(0.0334)	(0.0483)
Intercept	-0.1824*	-0.0364	0.0194*	0.0646	0.1090*	0.0887*	0.8240*	0.1129*
	(0.0820)	(0.0572)	(0.0060)	(0.0501)	(0.0530)	(0.0149)	(0.0644)	(0.0393)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.5. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 2 (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.0875*	0.0462*	-0.0040*	0.0110	-0.0079	-0.0111*	-0.1171*	-0.0018*
	(0.0172)	(0.0118)	(0.0012)	(0.0104)	(0.0111)	(0.0031)	(0.0136)	(0.0080)
Cos	0.0019	0.0031	0.0000	0.0066*	-0.0068*	0.0022*	-0.0006	-0.0064
	(0.0031)	(0.0022)	(0.0002)	(0.0019)	(0.0020)	(0.0006)	(0.0025)	(0.0016)
Sin	-0.0011	0.0020	0.0005*	-0.0024	0.0074*	0.0019*	-0.0049*	-0.0034*
	(0.0031)	(0.0023)	(0.0002)	(0.0019)	(0.0020)	(0.0006)	(0.0025)	(0.0015)
t	-0.0001	-0.0002	0.0000	0.0001	0.0002*	0.0000	0.0000	-0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0000)
R-squared	0.1665	0.2115	0.2167	0.1027	0.1313	0.5358	0.3399	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.6. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 3

Price of	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0195	0.0000	-0.0142*	0.0155	-0.0050	-0.0063	-0.0044	-0.0051
	(0.0482)	(0.0380)	(0.0059)	(0.0386)	(0.0310)	(0.0105)	(0.0381)	(0.0297)
Pork	0.0000	-0.0561	0.0090	-0.0109	-0.0100	-0.0079	0.0149	0.0610*
	(0.0380)	(0.0529)	(0.0060)	(0.0420)	(0.0315)	(0.0110)	(0.0374)	(0.0323)
Beans	-0.0142*	0.0090	-0.0002	0.0041	-0.0003	0.0008	-0.0006	0.0014
	(0.0059)	(0.0060)	(0.0031)	(0.0076)	(0.0051)	(0.0016)	(0.0050)	(0.0061)
Poultry	0.0155	-0.0109	0.0041	0.1022	0.0767*	0.0108	-0.0785*	-0.1199*
	(0.0386)	(0.0420)	(0.0076)	(0.0673)	(0.0364)	(0.0116)	(0.0409)	(0.0379)
Fish and Seafood	-0.0050	-0.0100	-0.0003	0.0767*	-0.1004*	0.0119	-0.0489	0.0761*
	(0.0310)	(0.0315)	(0.0051)	(0.0364)	(0.0355)	(0.0090)	(0.0321)	(0.0258)
Eggs	-0.0063	-0.0079	0.0008	0.0108	0.0119	0.0317*	-0.0251*	-0.0159*
	(0.0105)	(0.0110)	(0.0016)	(0.0116)	(0.0090)	(0.0046)	(0.0113)	(0.0088)
Dairy	-0.0044	0.0149	-0.0006	-0.0785*	-0.0489	-0.0251*	0.1345*	0.0082
	(0.0381)	(0.0374)	(0.0050)	(0.0409)	(0.0321)	(0.0113)	(0.0546)	(0.0295)
Other Meats	-0.0051	0.0610*	0.0014	-0.1199*	0.0761*	-0.0159*	0.0082	-0.0057
	(0.0297)	(0.0323)	(0.0061)	(0.0379)	(0.0258)	(0.0088)	(0.0295)	(0.0413)
Intercept	-0.0055	0.0347	0.0043	-0.0094	-0.0042	0.0448*	0.7430*	0.1923*
	(0.0710)	(0.0534)	(0.0058)	(0.0528)	(0.0535)	(0.0183)	(0.0693)	(0.0377)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.6. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 3 (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.0470*	0.0249*	-0.0011	0.0307*	0.0205*	-0.0022	-0.0973*	-0.0225*
	(0.0147)	(0.0110)	(0.0012)	(0.0109)	(0.0111)	(0.0038)	(0.0144)	(0.0078)
Cos	-0.0091*	0.0056*	0.0004*	0.0088*	-0.0041*	0.0019*	-0.0009	-0.0027*
	(0.0024)	(0.0018)	(0.0002)	(0.0018)	(0.0018)	(0.0006)	(0.0024)	(0.0013)
Sin	-0.0020	0.0006	0.0006*	-0.0026	0.0024	0.0010*	-0.0012	0.0011
	(0.0024)	(0.0019)	(0.0002)	(0.0018)	(0.0018)	(0.0006)	(0.0023)	(0.0013)
t	-0.0001	-0.0001	0.0000*	0.0000	0.0000	0.0000	0.0001	0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)
R-squared	0.2815	0.1883	0.2078	0.1773	0.0626	0.5164	0.3140	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.7. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 4

Price of	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0200	-0.0121	-0.0031	0.0599	-0.0326	-0.0050	-0.0120	-0.0150
	(0.0721)	(0.0467)	(0.0055)	(0.0455)	(0.0375)	(0.0109)	(0.0460)	(0.0349)
Pork	-0.0121	0.0462	0.0117*	0.0025	0.0059	-0.0014	-0.0728*	0.0199
	(0.0467)	(0.0580)	(0.0053)	(0.0451)	(0.0332)	(0.0108)	(0.0383)	(0.0353)
Beans	-0.0031	0.0117*	0.0017	0.0023	0.0042	0.0014	-0.0062	-0.0121*
	(0.0055)	(0.0053)	(0.0027)	(0.0069)	(0.0044)	(0.0014)	(0.0044)	(0.0055)
Poultry	0.0599	0.0025	0.0023	0.0007	0.0458	-0.0111	-0.0864*	-0.0136
	(0.0455)	(0.0451)	(0.0069)	(0.0719)	(0.0376)	(0.0114)	(0.0422)	(0.0413)
Fish and Seafood	-0.0326	0.0059	0.0042	0.0458	-0.0866*	0.0132	-0.0105	0.0606*
	(0.0375)	(0.0332)	(0.0044)	(0.0376)	(0.0358)	(0.0082)	(0.0319)	(0.0270)
Eggs	-0.0050	-0.0014	0.0014	-0.0111	0.0132	0.0294*	-0.0218*	-0.0047
	(0.0109)	(0.0108)	(0.0014)	(0.0114)	(0.0082)	(0.0037)	(0.0098)	(0.0089)
Dairy	-0.0120	-0.0728*	-0.0062	-0.0864*	-0.0105	-0.0218	0.2491*	-0.0395
	(0.0460)	(0.0383)	(0.0044)	(0.0422)	(0.0319)	(0.0098)	(0.0526	(0.0311)
Other Meats	-0.0150	0.0199	-0.0121*	-0.0136	0.0606*	-0.0047	-0.0395	0.0043
	(0.0349)	(0.0353)	(0.0055)	(0.0413)	(0.0270)	(0.0089)	(0.0311)	(0.0454)
Intercept	-0.3540*	-0.0099	0.0020	0.2016*	0.0799	0.0500*	0.8681*	0.1623*
	0.1100	0.0667	0.0061	0.0645	0.0664	0.0168	0.0745	0.0469

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.7. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 4 (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.1188*	0.0317*	-0.0001	-0.0121	0.0020	-0.0042	-0.1199*	-0.0162
	(0.0216)	(0.0129)	(0.0012)	(0.0125)	(0.0131)	(0.0033)	(0.0147)	(0.0091)
Cos	-0.0153*	0.0057*	0.0000	0.0082*	0.0028	0.0016*	-0.0002	-0.0028
	(0.0032)	(0.0020)	(0.0002)	(0.0020)	(0.0020)	(0.0005)	(0.0022)	(0.0015)
Sin	-0.0007	-0.0002	0.0002	-0.0025	0.0052*	0.0011*	-0.0046*	0.0016
	(0.0033)	(0.0020)	(0.0002)	(0.0020)	(0.0020)	(0.0005)	(0.0022)	(0.0014)
t	-0.0001	-0.0001	0.0000	-0.0002	0.0001	0.0000	0.0002	0.0001
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)
R-squared	0.2968	0.0897	0.2407	0.1050	0.0504	0.6484	0.3857	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.8. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 5

	Demand for							
Price of	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Beef	0.0775	-0.0337	0.0021	0.0224	-0.0023	-0.0153*	-0.0249	-0.0258
	(0.0577)	(0.0392)	(0.0045)	(0.0389)	(0.0339)	(0.0092)	(0.0397)	(0.0295)
Pork	-0.0337	0.1351*	0.0072	-0.0164	-0.0278	0.0039	-0.1056*	0.0373
	(0.0392)	(0.0515)	(0.0044)	(0.0395)	(0.0305)	(0.0094)	(0.0341)	(0.0308)
Beans	0.0021	0.0072	0.0046*	-0.0120*	0.0063*	0.0008	-0.0034	-0.0054
	(0.0045)	(0.0044)	(0.0023)	(0.0058)	(0.0037)	(0.0011)	(0.0037)	(0.0047)
Poultry	0.0224	-0.0164	-0.0120*	0.0137	0.0947*	0.0172*	-0.0930*	-0.0265
	(0.0389)	(0.0395)	(0.0058)	(0.0620)	(0.0338)	(0.0098)	(0.0371)	(0.0350)
Fish and Seafood	-0.0023	-0.0278	0.0063*	0.0947*	-0.0474	-0.0027	-0.0369	0.0163*
	(0.0339)	(0.0305)	(0.0037)	(0.0338)	(0.0357)	(0.0075)	(0.0306)	(0.0248)
Eggs	-0.0153*	0.0039	0.0008	0.0172*	-0.0027	0.0192*	-0.0176*	-0.0056
	(0.0092)	(0.0094)	(0.0011)	(0.0098)	(0.0075)	(0.0032)	(0.0086)	(0.0077)
Dairy	-0.0249	-0.1056*	-0.0034	-0.0930*	-0.0369	-0.0176*	0.3014*	-0.0199
	(0.0397)	(0.0341)	(0.0037)	(0.0371)	(0.0306)	(0.0086)	(0.0476)	(0.0273)
Other Meats	-0.0258	0.0373	-0.0054	-0.0265	0.0163*	-0.0056	-0.0199	0.0296
	(0.0295)	(0.0308)	(0.0047)	(0.0350)	(0.0248)	(0.0077)	(0.0273)	(0.0386)
Intercept	-0.3394*	0.0338	0.0026	0.2173*	0.0816	0.0547*	0.8833*	0.0661
	(0.0945)	(0.0597)	(0.0052)	(0.0592)	(0.0683)	(0.0155)	(0.0718)	(0.0441)

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.8. Parameter Estimates from Time-Varying AIDS Model for Household Income Quintile 5 (Continued)

	Demand for Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
b	0.1137*	0.0183	0.0001	-0.0156	0.0065	-0.0066*	-0.1185*	0.0021
	(0.0181)	(0.0114)	(0.0010)	(0.0113)	(0.0132)	(0.0030)	(0.0138)	(0.0085)
Cos	-0.0076*	0.0043*	0.0004*	0.0049*	0.0016	0.0008*	0.0018	-0.0062*
	(0.0026)	(0.0017)	(0.0002)	(0.0017)	(0.0019)	(0.0004)	(0.0020)	(0.0013)
Sin	-0.0018	0.0013	0.0000	-0.0030*	0.0035*	0.0011*	-0.0016	0.0005
	(0.0026)	(0.0018)	(0.0002)	(0.0017)	(0.0019)	(0.0004)	(0.0020)	(0.0013)
t	-0.0003*	0.0000	0.0000	-0.0001	0.0000	0.0001*	0.0003*	0.0001*
	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)
R-squared	0.3291	0.1622	0.3033	0.1336	0.0341	0.6688	0.4586	

Note: Single asterisk (*) denotes variables statistical significant at 10%; Standard errors are in parentheses.

Table 4.9. Own-Price Elasticities of Demand for Protein Sources across Different Income Strata Pre- and Post-October 2009

	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Pre-Oct.2009								
Average household	-0.6041	-0.7140	0.0922	-0.7641	-1.6979	-0.1657	0.0640	-1.1329
	(0.1494)	(0.2076)	(0.5580)	(0.3076)	(0.1884)	(0.0598)	(0.0869)	(0.1851)
Income Quintile 1	-0.7606	-0.6760	1.7225	-0.1358	-1.5358	-0.0681	0.0908	-1.0183
	(0.3032)	(0.4027)	(1.1388)	(0.5678)	(0.4892)	(0.1242)	(0.2120)	(0.4053)
Income Quintile 2	-0.4560	-1.1869	-1.3724	-1.4817	-1.7316	-0.3828	-0.3613	-1.1625
	(0.3212)	(0.4249)	(1.0043)	(0.5544)	(0.4272)	(0.1150)	(0.1810)	(0.4210)
Income Quintile 3	-0.9018	-1.3935	-1.0460	-0.1674	-2.0454	-0.0679	-0.3235	-1.0085
	(0.2318)	(0.3665)	(1.0277)	(0.5484)	(0.3689)	(0.1331)	(0.1761)	(0.3379)
Income Quintile 4	-0.6912	-0.6596	-0.2507	-0.9748	-1.8858	-0.0232	0.1264	-1.1367
	(0.3147)	(0.4272)	(1.1989)	(0.5758)	(0.3658)	(0.1220)	(0.1605)	(0.3979)
Income Quintile 5	-0.4100	0.0751	1.2870	-0.8643	-1.4240	-0.2898	0.2733	-1.2979
	(0.2614)	(0.4123)	(1.1446)	(0.4926)	(0.3158)	(0.1160)	(0.1428)	(0.3386)

Note: Single asterisk (*) denotes variables statistical significant different from pre- to post-Oct.2009 at 10%; Standard errors are in parentheses.

Table 4.9. Own-Price Elasticities of Demand for Protein Sources across Different Income Strata Pre- and Post-October 2009 (Continued)

	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Post-Oct.2009								
Average household	-0.5421*	-0.6890*	-0.3399*	-0.7701	-1.7217*	-0.3660*	0.0306*	-1.1229
	(0.1733)	(0.2211)	(0.3369)	(0.3004)	(0.1949)	(0.0454)	(0.0846)	(0.1714)
Income Quintile 1	-0.7263	-0.6372	0.8141*	-0.1883	-1.5438	-0.2561*	0.0668*	-1.0181
	(0.3457)	(0.4381)	(0.7593)	(0.5342)	(0.4882)	(0.0995)	(0.2080)	(0.3962)
Income Quintile 2	-0.4012	-1.1948	-1.2381	-1.4548	-1.7620	-0.5173*	-0.3871*	-1.1608
	(0.3618)	(0.4593)	(0.6463)	(0.5215)	(0.4465)	(0.0903)	(0.1769)	(0.4149)
Income Quintile 3	-0.8867	-1.4310	-1.0277	-0.1851	-2.0847*	-0.2808*	-0.3502*	-1.0074
	(0.2654)	(0.4011)	(0.6535)	(0.5323)	(0.3836)	(0.1027)	(0.1698)	(0.3086)
Income Quintile 4	-0.6434	-0.6441	-0.5834	-0.9781	-1.9411*	-0.2732*	0.1004*	-1.1215
	(0.3711)	(0.4408)	(0.6665)	(0.5759)	(0.3886)	(0.0909)	(0.1577)	(0.3559)
Income Quintile 5	-0.2960*	0.1484*	0.2059*	-0.8673	-1.4365	-0.4888*	0.2362*	-1.2713
	(0.3116)	(0.4386)	(0.6036)	(0.4942)	(0.3256)	(0.0833)	(0.1392)	(0.3086)

Note: Single asterisk (*) denotes variables statistical significant different from pre- to post-Oct.2009 at 10%; Standard errors are in parentheses.

Table 4.10. Expenditure Elasticities of Demand for Protein Sources across Different Income Strata Pre- and Post-October 2009

	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Pre-Oct.2009								
Average household	1.4060	1.3650	0.6096	0.9774	1.0899	0.9406	0.6028	0.8462
	(0.0728)	(0.0676)	(0.3401)	(0.0782)	(0.0940)	(0.0762)	(0.0371)	(0.0703)
Income Quintile 1	1.3101	1.2193	1.3432	0.9471	1.3160	0.7447	0.6774	0.8861
	(0.0683)	(0.0620)	(0.3264)	(0.0676)	(0.1189)	(0.0747)	(0.0428)	(0.0764)
Income Quintile 2	1.4369	1.3000	-0.1312	1.0904	0.9174	0.6984	0.6085	0.9458
	(0.0858)	(0.0768)	(0.3484)	(0.0848)	(0.1167)	(0.0848)	(0.0454)	(0.0906)
Income Quintile 3	1.2293	1.1723	0.6377	1.2497	1.2136	0.9371	0.6819	0.7464
	(0.0718)	(0.0765)	(0.3940)	(0.0886)	(0.1154)	(0.1111)	(0.0471)	(0.0875)
Income Quintile 4	1.5825	1.2316	0.9585	0.9029	1.0206	0.8624	0.6181	0.8189
	(0.1060)	(0.0938)	(0.5122)	(0.1006)	(0.1336)	(0.1079)	(0.0468)	(0.1014)
Income Quintile 5	1.5698	1.1462	1.0682	0.8755	1.0571	0.7619	0.6295	1.0239
	(0.0909)	(0.0908)	(0.4903)	(0.0901)	(0.1164)	(0.1078)	(0.0433)	(0.0969)

Note: Single asterisk (*) denotes variables statistical significant different from pre- to post-Oct.2009 at 10%; Standard errors are in parentheses.

Table 4.10. Expenditure Elasticities of Demand for Protein Sources across Different Income Strata Pre- and Post-October 2009 (Continued)

	Beef	Pork	Beans	Poultry	Fish and Seafood	Eggs	Dairy	Other Meats
Post-Oct.2009								
Average household	1.4555*	1.3932*	0.7642	0.9779	1.0927	0.9549	0.6194*	0.8568*
	(0.0817)	(0.0728)	(0.2055)	(0.0763)	(0.0970)	(0.0579)	(0.0355)	(0.0655)
Income Quintile 1	1.3449*	1.2405*	1.2286	0.9503	1.3136*	0.7958*	0.6882*	0.8882
	(0.0760)	(0.0680)	(0.2174)	(0.0636)	(0.1179)	(0.0598)	(0.0413)	(0.0750)
Income Quintile 2	1.4745*	1.3278*	0.2698*	1.0852	0.9136	0.7637*	0.6242*	0.9465
	(0.0932)	(0.0839)	(0.2249)	(0.0799)	(0.1221)	(0.0664)	(0.0436)	(0.0895)
Income Quintile 3	1.2575*	1.1895*	0.7694	1.2430*	1.2212*	0.9515	0.6979*	0.7661*
	(0.0806)	(0.0841)	(0.2508)	(0.0862)	(0.1195)	(0.0858)	(0.0447)	(0.0807)
Income Quintile 4	1.6535*	1.2409*	0.9769	0.9030	1.0219	0.8976	0.6309*	0.8370*
	(0.1189)	(0.0976)	(0.2848)	(0.1004)	(0.1419)	(0.0803)	(0.0452)	(0.0913)
Income Quintile 5	1.6486*	1.1562	1.0360	0.8754	1.0588	0.8291*	0.6455*	1.0218
	(0.1035)	(0.0970)	(0.2585)	(0.0902)	(0.1198)	(0.0774)	(0.0414)	(0.0881)

Note: Single asterisk (*) denotes variables statistical significant different from pre- to post-Oct.2009 at 10%; Standard errors are in parentheses.

CHAPTER V

CONCLUSIONS

Consumer purchasing behavior is influenced by a broad range of factors, including demographic, psychological, and environmental factors, as well as prior experience. Consumers are often more likely to rely on personal sources of information to make actual purchase decisions (Srinivasan, 2011). It follows that marketing strategies should ascertain how consumers gain knowledge and use information from external sources. Marketers are interested in consumer perceptions of brands, packaging, product practices, labeling and pricing.

Though consumers are concerned about hormone use in meat animals, this dissertation suggests that most are not well-informed regarding actual use of hormones in production. The results indicate that respondents underestimate the extent of hormone use in cattle production and overestimate the extent of hormone use in pork and chicken production.

Consumer perceptions of hormone use prevalence in different meat animal species are shown to be an important factor in meat demand. Results reveal that relative preferences for unlabeled meat products over NAH labeled meat products from cattle, hogs and chickens are negatively related to consumers' utility. Meat demand is also affected by consumers' misbeliefs about hormone use in different livestock species and demand for pork and poultry is unduly hampered by false beliefs about hormone use.

Consumers are willing to pay more for meat products labeled as NAH, relative to unlabeled products, and WTP premiums for "hormone free" pork and poultry are inflated as a result of inaccurate perceptions. Although producers may gain premiums from NAH labels on pork or poultry products, demand in general for pork and poultry may be dampened by consumers' misperception of hormone use. The NAH labels may actually perpetuate consumers' misperception of hormone use in pork and poultry production.

This research indicates that information about actual hormone use in meat production can impact meat demand. Results reveal that utility for unlabeled beef products is lower after consumers learn that more than 90% of cattle received added hormones, while utility for unlabeled pork and chicken products is higher after consumers learn that hormones are not used in pork and chicken production. Demand for beef products available in the choice experiment decreases while demand for pork and chicken products increases after consumers receive actual hormone use information.

Consumers are willing to pay more for NAH labeled meat products, relative to unlabeled products, both before and after receiving actual hormone use information. However, WTP premiums for NAH labeled pork chops and chicken wings become lower after consumers are provided with information that no hormones are used in pork and chicken production.

Educating consumers with factual information about food production will better aid consumers in satisfying their needs. If consumers are given actual food production information, the feedback of demand for food attributes will provide producers with better information to identify attributes of value to consumers. This is important to producers in marketing their products and anticipating sales.

“No added hormones” labels may lead consumers to believe that NAH labeled meat products are different or healthier than similar unlabeled products, while in reality, all poultry and pork products are NAH. In fact, the claim "no added hormones" cannot be used on the labels of pork or poultry unless it is followed by a statement that says "Federal regulations prohibit the use of hormones." (USDA, 2015). However, manufacturers may shrink, minimize, or obscure this statement of clarification, so it is hard for consumers to notice such clarification. However, this research indicates such clarification influences consumer meat preferences. Therefore, regulating labeling claims to deliver correct information effectively to consumers is important. Policy makers may wish to revisit the impact of NAH labels on pork or poultry products. This research implies that the premiums from NAH labels on pork and poultry products could evaporate if consumers have correct knowledge of hormone use in pork and poultry production.

Results from this research suggests that household expenditure patterns on protein sources may have been affected by the Great Recession, though response to the recession may not have been immediate because household eating habits change gradually and because the recession happened over time rather than at a point in time. Structural change tests employed in this dissertation suggests the break date of expenditure patterns for protein sources at October 2009.

The consideration of time trends in protein source expenditure shares indicates that the average household will purchase less beef and more fish and seafood, eggs and dairy products in the future. On average, households will expend more on non-red meat and protein intake will be from a more diversified set of protein sources, including eggs and dairy products. This dissertation also indicates that own-price and expenditure elasticities for protein sources change after October 2009. Changes of own-price and expenditure elasticities for protein sources are different for households across income quintiles. Interestingly, for households in Income Quintile 2, an increase in protein source expenditure decreases quantity demanded for beans pre-October 2009 but has the opposite effect post-October 2009.

Given that most consumers have little direct involvement in food production, many food choices are likely made with inaccurate beliefs regarding production claims. This work highlights the impacts that misperceptions can have on food choice and on willingness-to-pay for those food choices. It also suggests that information about food production provided to consumers can impact food demand. In addition, this dissertation examines changes in elasticities of demand for protein sources induced by income pressures— in this case, the Great Recession.

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